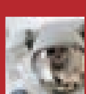
National Aeronautics and Space Administration

Johnson Space Center 2004 Implementation Plan



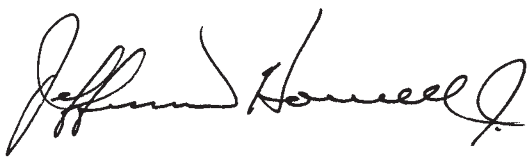
Message from the Center Director

Jefferson D. Howell, Jr.
Director
Lyndon B. Johnson
Space Center

On February 1, 2003, the Johnson Space Center tragically lost seven courageous and dedicated members of our family. Rick. Willie. Mike. K.C. Dave. Laurel. Ilan. Since the *Columbia* accident, our community has received the generous support of federal, state and local officials; volunteers from across the nation; and our international partners. The Johnson Space Center is deeply indebted to the selfless efforts of all those who committed their time and their lives in search of recovering the *Columbia* and her crew.

The Johnson Space Center is resolute in our commitment to safely pursue human space flight to further the noble efforts of the *Columbia*, *Challenger* and *Apollo 1* crews. We dedicate our efforts to the memories of these valiant men and women who devoted their lives to scientific knowledge, education and exploration. We will not only fix the problems that were identified by the *Columbia* Accident Investigation Board; we will also rely on our integrity, respect, professional excellence and commitment to identify and correct other technical and cultural issues so that we may safely return the Space Shuttle to flight and safeguard the Expedition crew on board the International Space Station.

Our greatest tribute to our heroic colleagues and our nation is to persevere in the quest for scientific knowledge, education and exploration. The Johnson Space Center will continue to make unique contributions across the world to improve life on Earth. We look forward to sharing our endeavors with you, and we welcome you as you read about our exciting capabilities and plans for the future.



Mission patches for *Apollo 1* (AS-204),
Challenger (STS-51L) and *Columbia* (STS-107).

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The Johnson Space Center: Enabling the NASA Vision and Mission

1 The Johnson Space Center: Enabling the NASA Vision and Mission

The Role of Johnson Space Center 1.1

For more than four decades, NASA's Johnson Space Center (JSC) has led the United States and the world in human exploration, discovery and achievement. JSC plays a vital role in transcending the physical boundaries of Earth, furthering knowledge and enhancing the quality of life.

The Center's team of dedicated professionals has made major advances in science, technology, engineering and medicine that enable humans to explore the world and universe as never before and to derive unparalleled benefits from that exploration.

The Lyndon B. Johnson Space Center in Houston, Texas, was established in 1961 as the Manned Spacecraft Center. In 1973, it was renamed in honor of the late President and Texas native Lyndon B. Johnson. Since its founding, JSC has been a pioneer in human space exploration and has led the nation's human space flight programs and projects, including Mercury, Gemini, Apollo, Skylab, Apollo-Soyuz, Space Shuttle, Shuttle-Mir and the International Space Station (ISS).

The Space Shuttle *Discovery's* cargo bay, the ISS and the Earth's horizon are reflected in the helmet visor of Astronaut Paul W. Richards, STS-102 mission specialist, while participating in an extravehicular activity during the flight's second spacewalk.

Among many other disciplines, the Center also leads worldwide research in extraterrestrial materials and the interaction between humans and robotics, as well as the biology and physiology of humans in space.

JSC's propulsion systems test facilities and many of its materials testing laboratories are located at the White Sands Test Facility (WSTF) in Las Cruces, New Mexico. This facility expands the Center's engineering capability with expertise in hazards assessment, rocket propulsion and chemical and physical properties testing of materials.

As one of NASA's ten field centers, JSC provides products and services that directly support NASA's efforts in scientific research and technology development.

Accomplishment of the NASA Vision and Mission 1.2

The NASA Strategic Plan establishes the strategic direction of the Agency and defines the alignment of its strategic and implementing documentation. The JSC Implementation Plan is part of this documentation.

The JSC Implementation Plan documents the roles and responsibilities of the Center, and provides a detailed review of the products and services that it provides in support of the Agency's programs and projects.

Government employees and contractors work together at JSC to contribute to the NASA vision and mission as One NASA. As a NASA field center, JSC also collaborates with other NASA field centers and NASA Headquarters, federal agencies, industry and academia to achieve the Agency's vision and mission.

NASA also establishes Agency goals based on the NASA vision and mission in the NASA Strategic Plan. NASA's Enterprises, and the field centers such as JSC that support these Enterprises, are responsible for achieving the NASA goals. The NASA Enterprises are guided by the NASA goals and are assigned to achieve these goals based on their core capabilities.

2

JSC Customers: Enterprises and Themes


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2 JSC Customers: Enterprises and Themes

The NASA Enterprises manage programs and projects organized by "Themes" that serve to achieve Agency goals. Although the Enterprises manage the work performed by the programs, various NASA field centers such as JSC provide products and services in support of the programs.

Every NASA Enterprise has published an Enterprise Strategy that describes its functions, roles, responsibilities and strategies for achieving the NASA goals and objectives. For more information related to the Enterprises, refer to the most recent Enterprise Strategy.

Figure 1 depicts the primary functions for which JSC provides products and services to the NASA Enterprises and Themes, and then aligns those functions with NASA's goals.

With his feet secured on a platform connected to the remote manipulator system (RMS) robotic arm of the Space Shuttle *Columbia*, Astronaut Michael J. Massimino, mission specialist, hovers over the Shuttle's cargo bay while working in tandem with Astronaut James H. Newman, mission specialist, during the STS-109 mission's second day of extravehicular activity.

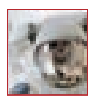


Figure 1: Johnson Space Center Alignment with the NASA 2003 Strategic Plan

All elements of NASA work together to achieve Agency goals, demonstrating the One NASA philosophy. The Agency goals are listed below, and all Themes are listed by Enterprise (at right). Elements of the matrix indicate each Theme's primary (■) and supporting (■) contributions and the Center's primary (●) and supporting (○) contributions.

NASA Mission	NASA Goals	
Understand and protect our home planet	1	Understand Earth's system and apply Earth system-science to improve the prediction of climate, weather, and natural hazards.
	2	Enable a safer, more secure, efficient, and environmentally friendly air transportation system.
	3	Create a more secure world and improve quality of life by investing in technologies and collaborate with other agencies, industry, and academia.
Explore the universe and search for life	4	Explore the fundamental principles of physics, chemistry, and biology through research in the unique natural laboratory of space.
	5	Explore the solar system and the universe beyond, understand the origin and evolution of life, and search for evidence of life elsewhere.
Inspire the next generation of explorers	6	Inspire and motivate students to pursue careers in science, technology, engineering, and mathematics.
	7	Engage the public in shaping and sharing the experience of exploration and discovery.
Enabling Goals	8	Ensure the provision of space access and improve it by increasing safety, reliability, and affordability.
	9	Extend the duration and boundaries of human space flight to create new opportunities for exploration and discovery.
	10	Enable revolutionary capabilities through new technology.

NASA Goals	NASA Enterprises																	
	Space Science					Earth Science		Biological and Physical Research			Aero Tech	Ed	Space Flight			Aerospace Technology		
	Solar System Exploration (SSE)	Mars Exploration Program (MEP)	Astronomical Search for Origins (ASO)	Structure and Evolution of the Universe (SEU)	Sun-Earth Connection (SEC)	Earth System Science (ESS)	Earth Science Applications (ESA)	Biological Sciences Research (BSR)	Physical Sciences Research (PSR)	Research Partnerships and Flight Support (RPFS)	Aeronautics Technology (AT)	Education Programs (EP)	International Space Station (ISS)	Space Shuttle Program (SSP)	Space and Flight Support (SFS)	Space Launch Initiative (SLI)	Mission and Science Measurement Technology (MSM)	Innovative Technology Transfer Partnerships (ITTP)
	Primary ○				Primary	Primary	Primary						Supporting ●	Supporting ●	Supporting ●			
											Primary							
							Supporting		Primary	Primary ●	Primary		Supporting ●		Supporting ●	Primary ○		Primary ○
								Primary ●	Primary				Supporting ●	Supporting ●				
	Primary ○	Primary ○	Primary	Primary	Primary									Supporting ●	Supporting ●			
	Supporting ○	Supporting ○	Supporting	Supporting	Supporting	Supporting	Supporting	Supporting ○	Supporting ○	Supporting ○	Supporting	Primary ●	Supporting ○	Supporting ○	Supporting ○	Supporting ○	Supporting	Supporting
	Supporting ○	Supporting ○	Supporting	Supporting	Supporting	Supporting	Supporting	Supporting ○	Supporting ○	Supporting ○	Supporting	Supporting ○	Supporting ○	Supporting ○	Supporting ○	Supporting ○	Supporting	Supporting
													Primary ●	Primary ●	Primary ●	Primary ●		
		Supporting ●						Primary ●	Primary ●				Primary ●	Supporting ●	Primary ●	Supporting ○	Supporting	
											Primary				Primary ●		Primary	Primary

Color and Symbol Key:

- Enterprise/Theme Primary
- Enterprise/Theme Supporting
- ● JSC Primary
- ○ JSC Secondary

The following section lists the Enterprises that JSC supports and describes the programs the Center supports in more detail.

Space Flight Enterprise 2.1

JSC's Role in the Space Flight Enterprise 2.1.1

JSC is one of four NASA field centers that are managed by the Space Flight Enterprise. The Center works closely with the other three field centers to achieve the primary goals supported by the Space Flight Enterprise.

The Director of JSC and the Directors of the other field centers managed by the Space Flight Enterprise serve on the Leadership Council for the Space Flight Enterprise. In this capacity, the field centers contribute to the overall direction and leadership for the Enterprise.

The Space Flight Enterprise has established four areas of emphasis that JSC is committed to supporting. These areas include:

Commitment to Flight

JSC's commitment to space flight is resolute. Through the Center's systematic safety and engineering practices, JSC will work with the rest of the Agency to fix the problems that were identified by the *Columbia* Accident Investigation Board and will correct other technical and cultural issues so the nation may safely return to flight.

The Space Flight Enterprise's Primary Contributions to NASA Goals

- Ensure and improve space access. (Goal 8)
- Extend the duration and boundaries of human space flight. (Goal 9)
- Enable revolutionary capabilities through new technology. (Goal 10)

Corporate Focus

JSC is part of an integrated organization with a common purpose. JSC will work with NASA Headquarters and other NASA field centers as One NASA to provide space flight capabilities that further NASA's goals, now and in the future.

Management Excellence

JSC, like the rest of NASA, is guided by the principles of the President's Management Agenda. JSC is committed to enabling constructive leadership and execution of its programs and projects through effective and efficient resource allocation.

Reaching for a Vibrant Future

Through commitment to space flight, a refined corporate focus and management excellence, NASA will be better enabled to develop the foundation for our future. JSC will enhance its capabilities to respond when new opportunities for exploration arise.

JSC's commitment to these areas of emphasis is documented throughout this JSC 2004 Implementation Plan.

Many of the Enterprise's programs are resident at JSC. Although these programs are managed by the Space Flight Enterprise, JSC plays a significant role in directly providing the programs with products and services, which are described in more detail in Chapter 4. Detailed descriptions of these programs follow.

Space Shuttle Program 2.1.2

The Space Shuttle is the most complex space vehicle ever designed and operated. It lifts off like a rocket, carries people and cargo into Earth orbit and lands on a runway like an airplane. After being serviced, the vehicle can fly again. This space transportation system has transformed the space frontier.

The Space Shuttle Program (SSP) system consists of the Space Shuttle Vehicle (SSV) elements, the Shuttle Carrier Aircraft, payload accommodations and ground support systems. The SSV consists of a reusable Orbiter vehicle with three installed Space Shuttle Main Engines, two reusable Solid Rocket

Boosters and reusable Solid Rocket Motors, and an expendable External Tank. The Program's functions, production and processing are performed in seven states and in Washington, D.C.

The Space Shuttle is designed to carry 55,000 pounds of cargo and seven people into space. Space Shuttle can perform a variety of missions, including:

- ISS assembly and support.
- Deployment and/or retrieval of payloads.
- Logistics transport and resupply.
- ISS crew rotation.

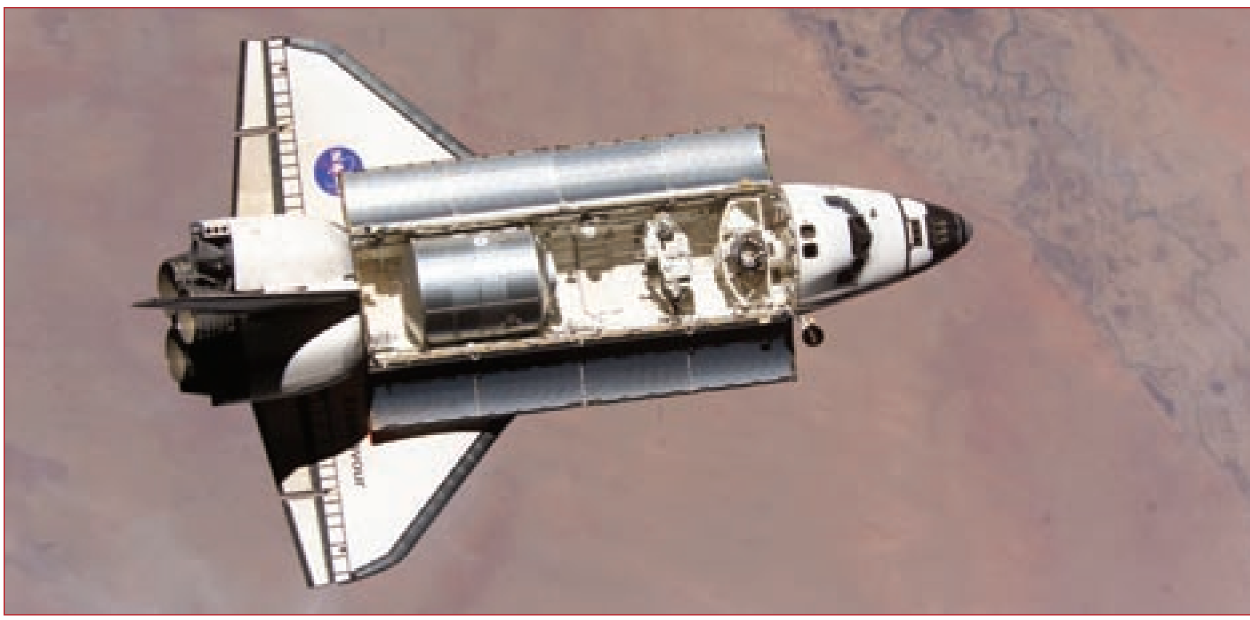
The Orbiter serves as a science and technology platform, can rendezvous and dock or berth, and can support missions of 16-plus days. The astronaut crewmembers can also perform spacewalks (also known as extravehicular activities (EVAs)) from the Orbiter to assemble, repair and service payloads in Earth orbit.

From its first flight in April 1981, the Space Shuttle has flown 113 flights. The Shuttle fleet has spent more than two-and-a-half years of total time in orbit and 15 years of passenger hours in flight. More than 850 payloads have flown, 65 payloads have been deployed, and more than 28 payloads have been retrieved, repaired, serviced and/or returned. The Shuttle has supported the Russian Mir space station and the ISS. There have been a total of five Orbiters in the history of the Space Shuttle fleet. Due to the *Challenger* and *Columbia* accidents, there are three Orbiters remaining: *Discovery*, *Atlantis* and *Endeavour*.

Although it has flown for more than two decades, the Space Shuttle still has three-quarters of its design life remaining. To maintain safe, robust capabilities in the Shuttle systems, the Program has initiated a Service Life Extension Program (SLEP). The SLEP policy is to assure safe and effective improvements to extend the Shuttle's useful life.

SLEP will identify and integrate issues and concerns across the SSP to establish a priority of investments required to fly safely. The focus of SLEP will be on safety and sustainability upgrades, as well as on infrastructure revitalization.

Return-to-flight (RTF) activities are currently under way. NASA will be guided by the *Columbia* Accident Investigation Board's (CAIB's) formal



The Space Shuttle *Endeavour* approaches the International Space Station. The Multi-Purpose Logistics Module, known as *Leonardo,* is visible in *Endeavour's* payload bay.

recommendations, which may be found on the Internet at http://www.nasa.gov/.

NASA's Implementation Plan for Space Shuttle Return to Flight and Beyond (the RTF Implementation Plan) documents corrective actions to address the CAIB recommendations and other critical actions that have been identified by NASA to enhance safety. The RTF Implementation Plan may also be found on the Internet at http://www.nasa.gov/. The RTF Implementation Plan is a living document and will be regularly updated with progress. As such, it will guide NASA's efforts to return to flight and to safely resume missions.

International Space Station Program 2.1.3

The ISS is a scientific laboratory orbiting 240 miles (390 kilometers) above the Earth that serves as a home to an international crew. Led by the United States, the ISS represents a global community united by the common goal of expanding human possibilities.

It is the most complex, international scientific and technological endeavor ever undertaken, involving five space agencies representing 16 nations working together in one of the greatest nonmilitary efforts in history. Once it is completed, this research laboratory in space will include contributions from the U.S., Russia, Canada, Japan, Brazil, Belgium, Denmark, France, Germany, Italy, the Netherlands, Norway, Spain, Sweden, Switzerland and the United Kingdom.

The elements of the ISS have been manufactured in facilities around the world. Assembly of the ISS elements in orbit began in 1998. Today, the ISS provides crewmembers with interior living and working space equal to that of a typical three-bedroom home. As a laboratory, the ISS serves as a test bed for future technologies; and its crews conduct scientific research on new, advanced industrial materials, communications technology, medical research and more.

Established as an unprecedented, state-of-the-art, orbiting laboratory, the ISS continues to expand the boundaries of space research. Its unique laboratory capabilities will lead to discoveries that will benefit people all over the world, now and for the future.

Since the *Columbia* accident, the assembly of the ISS has been discontinued until safe Shuttle flights can be resumed. However, the ISS continues to serve as a platform for scientific research, while maintaining a focus of safe operations with a crew

Backdropped against the blackness of space and Earth's horizon, the International Space Station was photographed through an aft flight deck window following separation from the Space Shuttle *Atlantis*.

of two. When the Shuttle can be safely returned to flight, ISS assembly will continue to expand the capabilities of the orbiting laboratory.

Rocket Propulsion Test Program 2.1.4

The Rocket Propulsion Test Program provides the core engineering and technology base to operate, maintain and enhance test facilities, rocket engines and engine components used in current flight vehicles, including the Space Shuttle and commercial vehicles. This program also tests future rocket propulsion technologies and systems.

Crew Health and Safety Program 2.1.5

The Crew Health and Safety Program protects the astronauts from the hazards of space travel and identifies methods that allow them to improve their performance. This program also systematically identifies and assesses critical health and safety risks and develops risk management solutions that enhance human health, safety and performance.

The Biological and Physical Research Enterprise's Primary Contributions to NASA Goals

- Create a more secure world and improve the quality of life by investing in technologies and collaborating with other agencies, industry and academia. (Goal 3)
- Explore the fundamental principles of physics, chemistry and biology through research in the unique natural laboratory of space. (Goal 4)
- Extend the duration and boundaries of human space flight to create new opportunities for exploration and discovery. (Goal 9)

Biological and Physical Research Enterprise 2.2

The Biological and Physical Research Enterprise has a unique role in all aspects of the Agency's vision and mission. Its fundamental and commercial research allows new knowledge, technologies and industries to improve life on Earth. Strategic research seeks innovation and solutions to enable the extension of life into deep space safely and productively. The Biological and Physical Research Enterprise sponsors interdisciplinary research in the unique laboratory of microgravity to address opportunities and challenges on Earth as well as in space environments.

Strategic research addresses topics such as radiation health and protection, bioastronautics and human support technologies aimed at sustained human exploration of space. For humans to venture beyond where we have been in space, NASA must provide the same kind of safe haven for space explorers that Earth provides. Understanding the challenge of adaptation of humans and other life forms to the effects of space flight is a critical role for the Biological and Physical Research Enterprise.

JSC provides products and services, described in more detail in Chapter 4, in support of the following program.

Bioastronautics Research 2.2.1

NASA is leading the world in exploring and understanding the space frontier, and in understanding the opportunities and the challenges this frontier presents for human exploration. Bioastronautics is a focused effort to enable the human exploration of space through effective risk management solutions and innovative, scientific and technological discoveries. It is NASA's vision to reach beyond the current boundaries of human space flight, to steadfastly ensure the safety, health and productivity of its space crews, and to use the knowledge gained in this quest to improve life on Earth.

Bioastronautics is the study of biological and medical effects of space flight on human systems. It establishes tolerance limits to the extreme environments of space and develops efficient and effective countermeasure strategies to overcome those limitations. Bioastronautics spans the research, operational and policy issues related to human space flight.

The Aerospace Technology Enterprise's Primary Contributions to NASA Goals

- Enable a safer, more secure, efficient and environmentally friendly air transportation system. (Goal 2)
- Create a more secure world and improve the quality of life by investing in technologies and collaborating with other agencies, industry and academia. (Goal 3)
- Ensure the provision of space access and improve it by increasing safety, reliability and affordability. (Goal 8)
- Extend the duration and boundaries of human space flight to create new opportunities for exploration and discovery. (Goal 9)
- Enable revolutionary capabilities through new technology. (Goal 10)

NASA envisions an outcome-driven program based on the Bioastronautics Critical Path Roadmap, which can be found on the Internet at http://criticalpath.jsc.nasa.gov/. This program is designed to ensure the safety, health and optimum performance of astronauts through systematic identification, assessment and management of critical risks associated with human space flight.

Realization of this program will provide the Agency and its stakeholders with risk management solutions for all mission scenarios, including Space Shuttle, extended-duration habitation of the ISS and future exploration missions. In addition, this pursuit will yield new opportunities for scientific discoveries and advanced technologies for understanding and overcoming human limitations to the hazardous environment of space.

Aerospace Technology Enterprise 2.3

The Aerospace Technology Enterprise has a significant role to play in meeting the challenges facing aerospace transportation. Advanced physics-based modeling, simulation, new materials and structural concepts, and other technologies will enable safer, more robust and affordable aircraft and spacecraft.

NASA has always been a leader in applying advanced technologies. The Aerospace Technology Enterprise applies technologies that enable safe, simplified space transportation and robust design and operating margins. These technologies allow the continued expansion of human and robotic exploration throughout the solar system. JSC provides support, discussed in more detail in Chapter 4, to the following programs.

Orbital Space Plane 2.3.1

NASA is revolutionizing our space transportation systems to significantly increase safety and reliability, while reducing cost, through its Space Launch Initiative. The design and development of a next-generation crew rescue and crew transport vehicle—an Orbital Space Plane (OSP)—is one of the objectives of the Space Launch Initiative. The OSP Program will develop more than a vehicle; it will develop the entire space transportation system, including ground operations and all supporting technologies needed to conduct missions to and from the ISS.

The ISS is a valuable resource for both scientific research and operational experience in the space environment. Access to the ISS is critical and, as experienced after the *Columbia* accident, vulnerable to disruption. To ensure access to space for the nation, the Aerospace Technology Enterprise has established the OSP Program, which is focused on developing technology for a crew return vehicle. Through an evolutionary development process, the OSP Program will continue with the development of a crew transfer vehicle to send humans into space and return them safely to Earth.

The strategy of the OSP is to accelerate technology development through flight demonstrators that will meet the most challenging aspects of developing a crewed space vehicle, including approach and landing, autonomous rendezvous and crew escape.

Innovative Technology Transfer Partnerships 2.3.2

The Innovative Technology Transfer Partnerships (ITTP) Theme serves all of the NASA Enterprises and supports their missions by facilitating the development of new technologies through partnerships with U.S. industry. The ITTP Theme consists of the Technology Transfer Activity, the Small Business Innovative Research (SBIR) program and the Small Business Technology Transfer (STTR) program.

The Technology Transfer Activity contributes to the Enterprise's needs, as well as to national economic strength, through innovative technology partnerships with non-aerospace industries. NASA will support efforts to document and license technologies and to make them available to the private sector. Further, the Agency will continue to advise entrepreneurs of technology offerings available for licensing and will solicit partnerships to meet Enterprise technology needs through the use of the Internet.

In 1982, Congress established the SBIR program to provide increased opportunities for small businesses in research and development, increased employment and competition. Specific program objectives are to stimulate U.S. technological innovation, to use small businesses to meet NASA's research and development needs, to increase private sector commercialization of innovation derived from federal research and development, and to foster and encourage participation by socially disadvantaged businesses.

The STTR program awards contracts to small business concerns for cooperative research and development with a research institution such as a university. The goal of Congress in establishing the STTR program is to facilitate the transfer of technology developed by a research institution through the entrepreneurship of a small business.

Space Science Enterprise 2.4

The Space Science Enterprise at NASA seeks to answer certain profound questions, namely:

- How did the universe begin and evolve?
- How did we get here?
- Where are we going?
- Are we alone in the universe?

The Space Science Enterprise is responsible for NASA's programs relating to astronomy, the solar system and the Sun and its interaction with Earth. JSC supports this Enterprise by providing products and services, described in more detail in Chapter 4, to the following Themes.

Solar System Exploration 2.4.1

Fundamental research performed by the Solar System Exploration Theme seeks to understand the:

The Space Science Enterprise's Primary Contributions to NASA Goals

- Understand the Earth system and apply Earth system science to improve prediction of climate, weather and natural hazards. (Goal 1)
- Explore the solar system and the universe beyond, understand the origin and evolution of life, and search for evidence of life elsewhere. (Goal 5)

- Nature and history of our solar system, and what makes Earth both similar to and different from its planetary neighbors.
- Origin and evolution of life on Earth.
- External forces, including comet and asteroid impacts, that affect life and the habitability of Earth.

Mars Exploration 2.4.2

NASA seeks to understand whether Mars was, is or can be a habitable world. To find this out, the Mars Exploration Theme is conducting research to understand how geologic, climatic and other processes have worked to shape Mars and its environment over time, as well as how these processes interact today. The key to understanding the past, present or future potential for life on Mars can be found in four broad, overarching goals for Mars exploration. These are to:

- Determine whether life ever existed on Mars.
- Characterize the climate of Mars.
- Characterize the geology of Mars.
- Prepare for human exploration of Mars.

By establishing education as a part of our core mission, we will help to counter the general decline in math and science skills that threatens the prosperity and security of future generations of Americans.

Sean O'Keefe, NASA Administrator

Education Enterprise 2.5

From the excitement of the countdown to awe-inspiring images of planets and galaxies, space exploration has a unique capacity to capture the imaginations of young and old alike. But the road to the planets does not begin at the launch pad; it begins at the classroom door.

In a world economy increasingly driven by information and technology, the U.S. capability in the fields of science, technology, engineering and mathematics will continue to serve as the cornerstone of much of our strength. At the same time, colleges in the U.S. are reporting a significant decline in degrees awarded in math, engineering and technology (source: U.S. Dept. of Education: The Condition of Education, 2002, page 197, NCES 2002-025). The United States needs the children of today to become the inventors of tomorrow, and NASA needs them to explore new worlds and improve life here on Earth.

If the United States is to lead in the scientific and technological advancements of the 21st century, NASA must focus on educating our young people—and inspire them to pursue the careers that make these accomplishments possible.

JSC provides products and services to the Education Enterprise through several activities described in more detail in Chapter 4.

The Education Enterprise's Primary Contributions to NASA Goals

- Inspire and motivate students to pursue careers in science, technology, engineering and mathematics. (Goal 6)
- Engage the public in shaping and sharing the experience of exploration and discovery. (Goal 7)

3 The JSC Workforce and Facilities


MISSION CONTROL CENTER
DIRECTOR

3 JSC Workforce and Facilities

JSC is a positive force in the community. A large workforce of federal and contract employees greatly influences the local economy. This workforce also enhances the quality of life in the area through community service, partnerships with industry and education programs.

The JSC Workforce 3.1

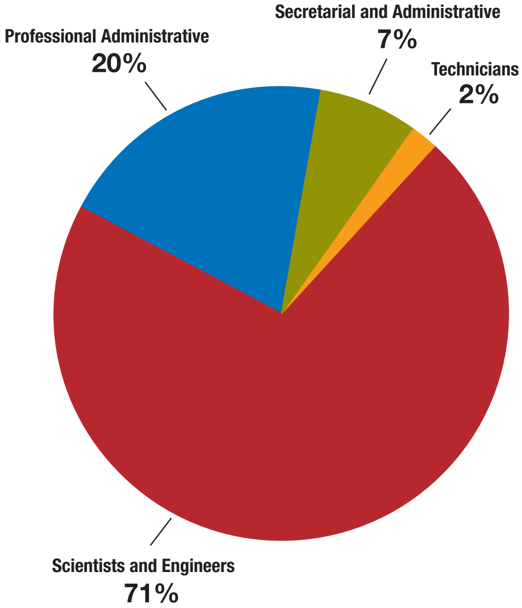
JSC boasts a committed and capable workforce poised to fulfill NASA goals in the areas of:

- Human Spacecraft Design and Development.
- Human Operations in Space.
- Bioastronautics, Space Science and Astromaterials.
- Education and Scientific Knowledge Advancement.

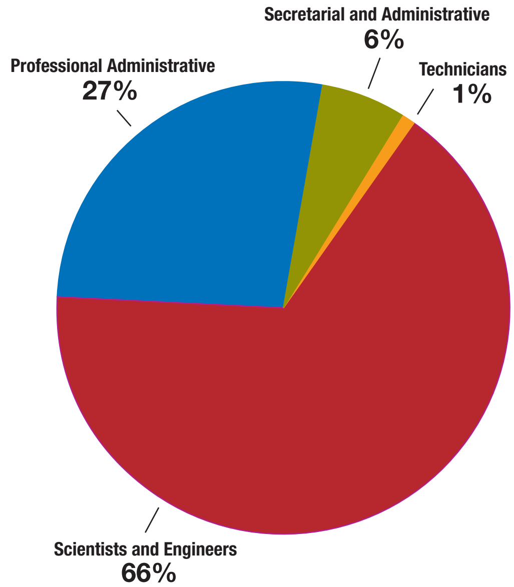
The expertise of the JSC workforce is concentrated in these four primary areas, which encompass JSC's core capabilities. The workforce, facilities, products and services of the Center are managed within this general structure.

Center management continues to assess the skills it needs to support future opportunities in JSC's core capabilities, such as the OSP, the SLEP, the Human Research Institute and the Space Radiation Initiative. Readiness for the future is ensured by implementation of a hiring strategy consistent with the Center's evolving goals and missions; recruitment and retention of the best employees;

The flight director and CAPCOM (capsule communicator) are pictured on console during the flight of STS-113.

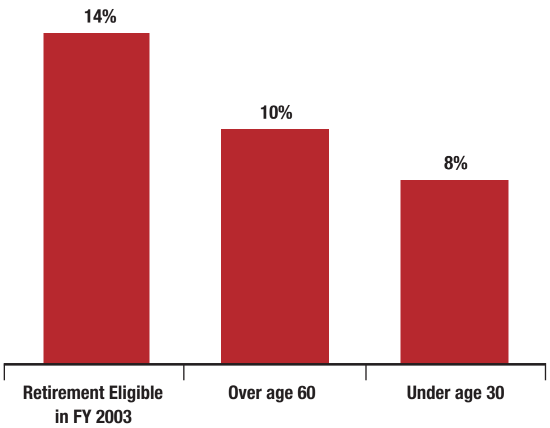


Major Occupational Groupings at JSC in 2003



Occupational Sources of Projected Turnover Through 2006

development of leaders; supplementation of the civil service workforce through partnerships with academia and private industry; and implementation of the Agency's Strategic Human Capital Plan.



JSC Workforce Age Profile in 2003

JSC's workforce is primarily made up of scientists and engineers. The average age of the overall workforce is 45.8 years with about 20.3 percent of the workforce eligible to retire by 2006. Given the current trends, about 13 percent of the Center's workforce is expected to turn over by 2006.

In 2003, JSC conducted a workforce and competency assessment to identify critical needs for the Center to meet its future challenges. As a result of this assessment, JSC will focus its efforts on mitigating skill gaps in areas related to:

- Space Shuttle RTF activities.
- Mission execution.
- Bioastronautics.
- Astromaterials and space sciences.
- Design, development and systems engineering.
- Business and technical support.

To address these gaps and to maintain the excellence of the workforce, JSC will apply an integrated set of human capital tools. Use of these tools will ensure that the Center has a committed, capable and diverse workforce in place to accomplish the technical and business management objectives set by the Agency.

Benefiting the Local Economy 3.1.1

Texas ranks first in total NASA dollars spent. In fiscal year 2000 (FY 2000), the Center contributed more than $2 billion to the local economy, largely through worker salaries, contracts, grants and local purchase of goods and services. Studies show that 16 percent of the local workforce is directly employed in the aerospace industry. JSC and contractor personnel are educated and highly skilled—84 percent have a bachelor's degree and 31 percent also hold at least one graduate degree.

At the end of FY 2000, 2,894 civil servants and 13,357 contractors were employed at or near JSC. A total of 633 companies and organizations worked on Center contracts, grants and agreements that year, including awards equaling $34 million to Texas colleges and universities and $3.6 million to nonprofit institutions.

An Active Community, Business and Education Partner 3.1.2

JSC plays a major role in community activities. The Center participates in technical expositions with industry, university and other professional groups to share and explore advanced technologies with their potential for wider commercial, government or academic use.

The human space flight mission provides an inspirational environment in which to learn engineering concepts, science and math. The Center's education programs for teacher development and student enrichment include partnerships with public and private schools and universities. In teacher workshops, hundreds of teachers from around the nation are given access to NASA resources and are trained in techniques for teaching science and math. Students find exciting, hands-on learning opportunities in special projects such as a robotics engineering competition, a Mars-Base Development activity and the KC-135 Reduced Gravity Student Flight Opportunity Program.

JSC Facilities 3.2

Development of the Lyndon B. Johnson Space Center began in September 1961. JSC is located in Houston, Texas, with facilities situated on its main campus near Clear Lake and with other facilities located at Ellington Field. JSC also manages test facilities at the WSTF located in Las Cruces, New Mexico.

Students participating in experiments as part of their studies in the KC-135 Reduced Gravity Student Flight Opportunity Program.

Real Property 3.2.1

The primary site of JSC is located on 1,580.8 acres of land in Houston, Texas. The Center, which has 165 buildings that provide for 3.7 million square feet, has a net worth of $466.1 million. The JSC facilities at Ellington Field are situated on 50.7 acres, and include 30 buildings comprising 543,451 square feet and a net worth of $58.8 million.

A comparison of real property at JSC and at WSTF to the total values for all NASA field sites is shown in Table 1.

The majority of JSC facilities were built in the mid-1960s, with some minor facility additions over the next 30 years. The most recent addition was the South annex to the Mission Control Center, which was constructed in the mid-1990s. Due to the aging infrastructure at JSC and to the reduced levels of maintenance funding over the past decade, JSC has seen a substantial increase in its backlog of maintenance and repair (BMAR).

The Agency facility condition index (FCI), which is a five-point scale of facility condition, is used to

Lyndon B. Johnson Space Center

Table 1: Comparison of Real Property				
Real Property Comparison of NASA Field Site	**JSC % of NASA Total**	**JSC Rank of 13 NASA Field Sites**	**WSTF % of NASA Total**	**WSTF Rank of 13 NASA Field Sites**
Total Land	0.5%	8	16.8%	3
Buildings	7.6%	5	3.4%	12
Facility Net Worth	7.8%	5	1.0%	12
Population	12.8%	2	1.0%	13

develop major facility repair requirements. In the FCI assessment in 2002, JSC scored 3.5 out of 5.0, where the NASA average is 3.6. JSC is ranked eighth of the 13 NASA centers in terms of average FCI.

The Center facilities maintenance budget is part of the facilities service pool that pays for a number of institutional services including maintenance and repair. Maintenance and repair is the top priority for this pool after other fixed costs, such as utilities, are budgeted.

A study initiated in 2002, currently under final review, was funded to provide a program and schedule for the total planned refurbishment of interiors of all office buildings at JSC. The study provided a comprehensive review of existing conditions of a selected prototype structure. Recommendations were provided for upgrading all building systems to current technology, which will extend the useful life of all buildings for another 40 years. The total NASA refurbishment program calls for the renovation of approximately 1.4 million square feet at a cost of $240 million.

JSC is planning for demolition of some facilities in FY 2004, FY 2005, FY 2006 and FY 2007. Some maintenance and repair funds will be saved as these facilities are demolished. The savings will enable the Center to better maintain existing facilities.

Plans for JSC Facilities 3.2.2

Internal Planning

JSC has been working to improve efficiency within its maintenance and repair program and to maintain its facilities in a more cost-effective manner by performing reliability centered maintenance (RCM). The Center has also requested and received a maintenance and repair funding augmentation to apply toward the reduction of BMAR. BMAR growth at JSC will be curtailed as a result of this funding augmentation, combined with the implementation of RCM.

In addition to the maintenance and repair funding augmentation, JSC has the means to demolish unessential facilities through the availability of an Agencywide demolition fund. JSC is planning for demolition of several facilities in the next four fiscal years, and some maintenance and repair funds will be saved as these facilities are demolished. These savings will enable the Center to better maintain its remaining essential facilities.

A study, initiated in 2002, was funded for the total planned refurbishment of interiors of all office buildings at JSC. The study, which provided a comprehensive review of existing conditions of a selected prototype structure, resulted in a recommendation to refurbish, rather than demolish and

rebuild, panel office structures. Recommendations, which will extend the useful life of all buildings for another 40 years, were provided for upgrading all building systems to current technology. Based on the results of this study, JSC has also produced a 20-year refurbishment plan for these facilities. Total facility refurbishments will include architectural upgrades, bringing JSC facilities current with Americans with Disabilities Act standards; total mechanical and electrical upgrades, which will increase energy efficiency; and upgrades to fire protection and asbestos and lead paint removal, which will improve the overall safety and reduce current maintenance and repair costs of the facilities.

External Partnership Opportunities

As part of the planning process, JSC's infrastructure is analyzed for its ability to support modifications to existing facilities or the building of new facilities. This information is documented in a Master Development Plan. Recommendations from outside entities help the Center to assess future uses of our capabilities, such as enhanced use leasing (EUL) and partnering with industry or universities.

By using Space Act Agreements and by proposing EUL strategies and public-private partnerships, JSC will maximize use of its non-NASA capital assets. Potential partners, such as contractors, local developers, universities and outside investors, and strategies are being identified for implementing opportunities, including the lease of land or facilities for the mutual benefit of both parties on facilities projects.

JSC's infrastructure will require a substantial amount of investment over the next several years to ensure its ability to support the Center's customers. The Real Property Business Plan identifies opportunities and provides the foundation for a strategy that will assist JSC in making the transition from an aging infrastructure to a highly supportive infrastructure.

Several opportunities were highlighted in the Real Property Business Plan. These opportunities, if implemented, will use existing underused land at JSC. Other opportunities exist for facilities and asset management. JSC can renovate an existing facility, relocate an off-site contractor and use the EUL proceeds to begin renovating other on-site facilities.

JSC Communications Infrastructure 3.2.3

The JSC communications infrastructure is comprised of voice and data network links and routing devices. The voice network was completely renovated within the last three years. Low-level maintenance is planned at a static level within current budgets. A major Centerwide upgrade of network systems, involving standards conversion and bandwidth increases, is currently 60 percent complete. Maintenance costs for the data network are approximated from historical and vendor data as 20 percent of the total value of the network.

JSC also manages an imaging services infrastructure that includes traditional analog and digital video systems, wet film chemical systems and digital still imagery systems. The Center thus provides the human space flight programs with direct mission support, including downlinked, or returned, video and still photography. The JSC video network is currently being serviced, and upgrades are planned over the course of the next several years. Upgrades to the cable television system are being planned to

Human Spacecraft Design and Development Facilities

- Thermal Vacuum Test Complex
  - Chamber A
  - Chamber B
- Electronic Systems Test Laboratory
- JSC Avionics Engineering Laboratory
- Energy Systems Test Area
- Electromagnetic Interference/Compatibility Laboratory
- Vibration and Acoustic Test Facility

allow for larger channel capacity and features such as video-on-demand. Plans are also being developed to increase bandwidth to allow for standard and high-definition digital signal distribution. Maintenance costs for the video network are approximated from historical and vendor data as 20 percent of the total value of the network.

Unique Facilities 3.2.4

Human Spacecraft Design and Development

JSC has several facilities that provide engineering design, development and test support to human-rated spacecraft, including the Space Shuttle and the ISS Programs. Some of these facilities are described in more detail below.

The **Thermal-Vacuum Test Complex** consists of two chambers, Chambers A and B. The facility provides full-scale testing of large systems, as well as human testing and training in a high-fidelity, simulated space environment. In addition to the chambers, a high bay area supports test article buildup and preparation for installation into the chambers. To support test articles, the facility has numerous thermal carts that are capable of providing precise thermal control to temperatures as low as 144 Kelvin.

Chamber A is the largest of the JSC thermal-vacuum test facilities. Its usable test volume and high-fidelity space simulation capabilities are adaptable for thermal-vacuum testing of a wide variety of test articles.

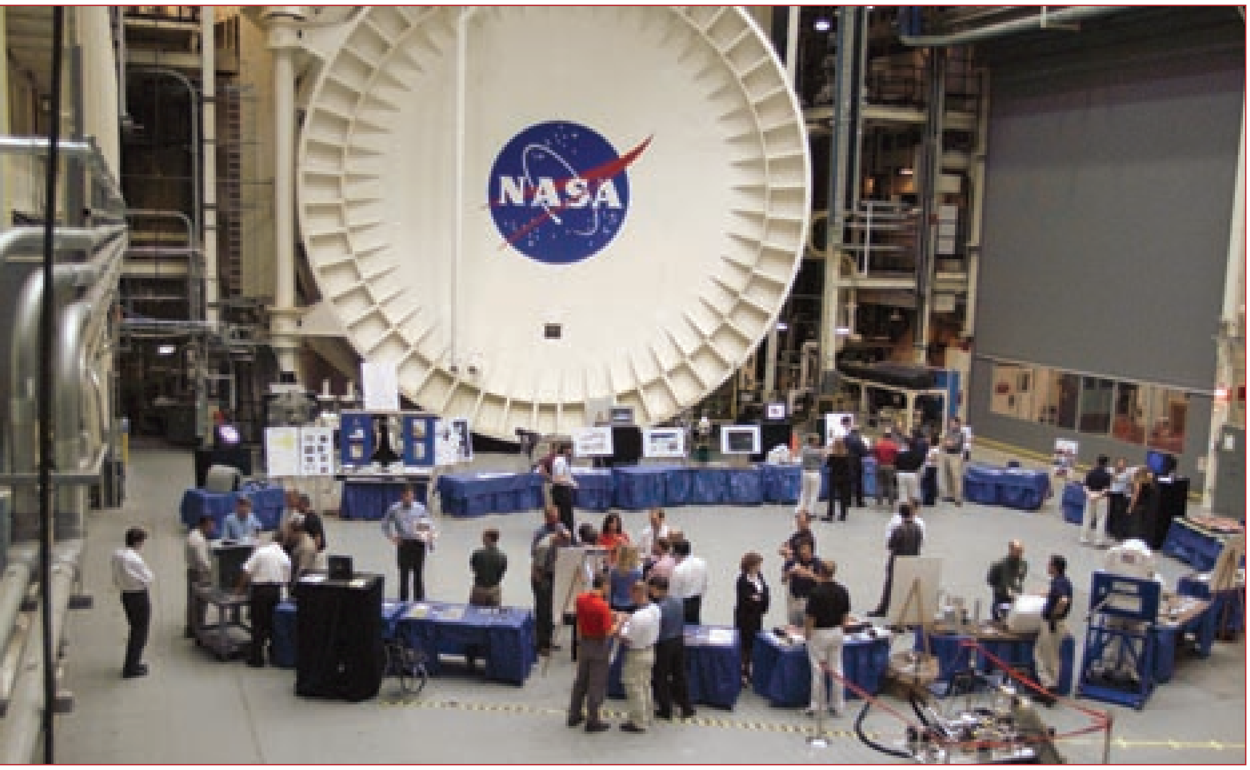
Chamber B, which has roughly one-tenth of the internal volume of Chamber A, can handle a variety of smaller-scale tests more economically and with faster response. It is the only human-rated thermal vacuum chamber in the world; and it continues to be used regularly to verify the viability of EVA construction activities. This is the only chamber in which procedures and design can be verified on large EVA flight hardware at full thermal and vacuum conditions, using a suited crewmember. This facility provides the highest fidelity simulation of the actual hardware conditions that can be achieved on the ground. Results of these tests are used to plan EVA procedures and to correct hardware flaws before they are launched.

The **Electronic Systems Test Laboratory** is a unique NASA facility in which multi-element, crewed spacecraft communications systems are integrated and tested using relay satellites and ground elements in a controlled radio frequency environment. This facility is used for design evaluation, radio frequency interface compatibility and system performance verification testing of spacecraft radio frequency communications systems and their interfaces with external elements, such as ground stations, relay satellites and detached payloads.

The **JSC Avionics Engineering Laboratory** (JAEL) is an engineering facility designed to support avionics flight system hardware and software development and evaluation. JAEL can support informal engineering evaluation as well as formal, configuration-controlled verification testing of both flight and non-flight hardware and software. JAEL provides a “bench”-level test environment and a flight-like environment that is capable of supporting both individual flight system component-level testing and integrated system-level testing of flight system components.

The **Energy Systems Test Area** (ESTA) is a multi-facility complex that provides environmental test services for hardware evaluation and problem solving. The ESTA facilities have remote control and sensing features and built-in blast protection that allow both development and out-of-limits testing. The facilities include many of the high-energy systems used in crewed spacecraft and planetary systems, such as fluid systems, cryogenics, pyrotechnics, batteries, fuel cells, chemical processes for in-situ resource utilization, electromechanical actuation, hydraulics and high-pressure hydrostatic and pneumostatic testing of components and fluid systems.

The **Electromagnetic Interference/Electromagnetic Compatibility** (EMI/EMC) **Laboratory** is



An overall view of the Return to Flight Repair Demonstration in Johnson Space Center's Space Environment Simulation Laboratory. Chamber A can be seen in the background. (Above)

Astronaut Joseph R. (Joe) Tanner, STS-115 mission specialist, uses the Sky-genie to lower himself from a simulated trouble-plagued Shuttle in an emergency egress training session in the Space Vehicle Mockup Facility at JSC. (At right)

Human Operations in Space Facilities

Crew Training

- Jake Garn Training Facility
- Space Vehicle Mockup Facility
- Space Station Training Facility
- Neutral Buoyancy Laboratory – Sonny Carter Training Facility
- Systems Engineering Simulator – Spacecraft Dynamics Simulation
- Mobile Remote Manipulator Development Facility
- Dexterous Manipulator Trainer
- EVA/RMS Virtual Reality Simulation Trainer

Crew Training and Hardware Certification

- Space Station Airlock Test Facility
- Shuttle Environmental Control Life Support System Test Article and the Shuttle Airlock Test Article
- Eleven-Foot Chamber
- Eight-Foot Chamber
- Two-Foot Thermal-Vacuum Spacesuit Boot/Glove Test Chamber

Ground Crew Training and Operations

- Mission Control Center
- Electrical Power Systems Laboratory
- Intelligent Systems Laboratory
- Software Technology Laboratory
- Integrated Planning System (IPS) and Flight Data File Production Facility

comprised of two EMI test chambers. The EMI/EMC Laboratory provides technical services to evaluate and certify flight hardware, ground support equipment and commercial off-the-shelf equipment for both the Shuttle and the ISS to achieve compliance with EMI requirements and EMC requirements at the component level.

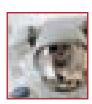
The **Vibration and Acoustic Test Facility** is used to empirically evaluate and certify hardware structural design and workmanship. It is capable of testing spacecraft components that are rigidly bolted to a planar interface on a single shaker and are subjected to a random vibration equivalent to a Shuttle or an ISS environment. The vibration environment can simulate broadband random vibrations induced in spacecraft by external acoustic or aerodynamic pressure, exert shock pulses to simulate ground handling and transportation, and identify resonance and broadband random environments other than mission conditions used to predict impending failures due to workmanship defects.

Human Operations in Space

Designing a training program to prepare astronauts for the unique challenges of working in microgravity presents its own set of challenges. Trainers must not only familiarize astronauts with complex and highly specialized flight vehicles, equipment and suits, but they must do this so as to simulate a microgravity working environment. Each of the training facilities is also used for on-orbit procedure development and validation.

Descriptions of the crew training facilities follow.

High-fidelity mockups housed in both the **Jake Garn Training Facility** and the **Space Vehicle Mockup Facility** are used to train astronauts in vehicle operations. Astronauts prepare for launch, landing, payload operation and rendezvous activities in the Garn Facility. A motion-based trainer simulates the vibrations, noise and views that astronauts will experience during launch and landing. A fixed-base simulator is used for rendezvous and



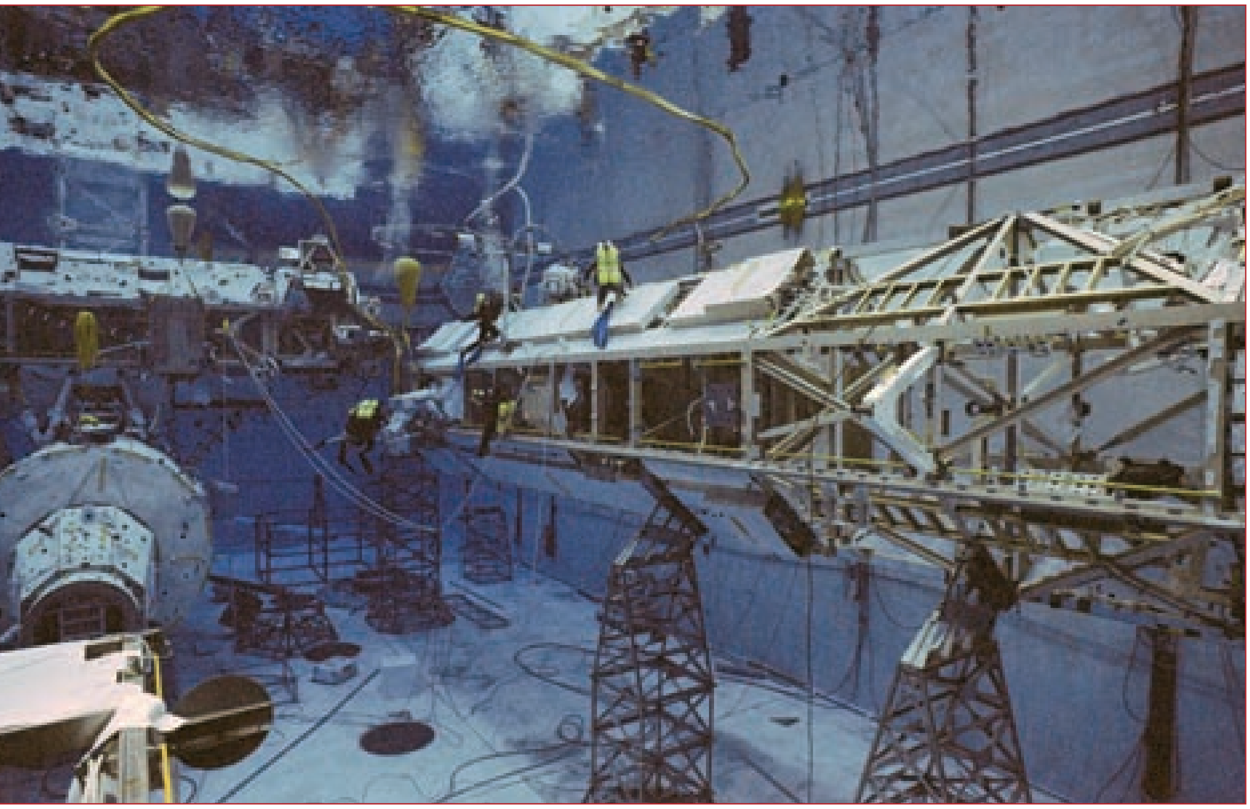
payload operations training. Typically, Shuttle crews get 350-400 hours of Garn Facility training for each flight.

The **Space Vehicle Mockup Facility** is home to two full-sized mockups of the Shuttle flight deck and middeck, as well as one full-sized Shuttle mockup. ISS mockups in this facility provide astronauts with a training environment similar to that they will experience in orbit. Before their first mission, astronauts typically spend a combined 300 hours in these training simulators.

A companion to the Garn Facility is the **Space Station Training Facility** (SSTF), which is a high-fidelity, flight software-based simulator that is used to prepare ISS and Shuttle astronauts for their interaction with the ISS. The SSTF is the only simulator in the ISS Program that brings together simulations of all International Partner elements with a representative selection of payloads and provides the astronauts and flight controllers with a unique, full-task simulation environment. ISS crewmembers receive 75-150 hours of training in the SSTF to prepare for their missions.

The world's largest indoor swimming pool is JSC's **Neutral Buoyancy Laboratory** (NBL), which is part of the **Sonny Carter Training Facility**. It holds 6.2 million gallons of water and is more than 200 feet long and 40 feet deep. The NBL simulates the weightless environment of space. Astronauts train on full-sized replicas of the ISS, Hubble Space Telescope and other payloads. They spend approximately 10 hours under water for every hour they will spend walking in space.

The **Systems Engineering Simulator (SES) Spacecraft Dynamics Simulation (SCDS)** provides a real-time, crew-in-the-loop engineering simulator for Space Shuttle, ISS and advanced programs. It provides the ability to test changes to



Astronauts Robert L. Curbeam, Jr., and Christer Fuglesang, STS-116 mission specialists, wearing training versions of the extravehicular mobility unit (EMU) spacesuit, participate in an underwater simulation of extravehicular activity scheduled for the 19th Shuttle mission to the International Space Station. Curbeam and Fuglesang are dwarfed by Station truss segments in this overall view of the simulation conducted in the Neutral Buoyancy Laboratory. Fuglesang represents the European Space Agency.

Astronaut Donald R. Pettit, Expedition Six flight engineer, participates in an extravehicular mobility unit spacesuit fit check in a Space Station Airlock Test Facility at JSC.

existing space vehicles and flight software, to test the interaction of a new vehicle system with existing systems, to create models of new vehicles for engineering analysis, and to evaluate displays and controls concepts and modifications. All of these functions are performed in a controlled, flexible development environment. In addition to engineering analysis work, the SES SCDS supports Space Shuttle and ISS crew training for the Remote Manipulator System (RMS), Space Station Remote Manipulator System (SSRMS) and rendezvous/proximity operations.

The **Mobile Remote Manipulator Development Facility** is a ground-based, full-scale, hydraulically driven replica of the SSRMS. It supports flight crew training, systems development and operations support activities.

The **Dexterous Manipulator Trainer** is a hydraulically driven, full-scale replica ISS Special Purpose Dexterous Manipulator System simulation facility for flight crew training, systems development and operations support activities.

The integrated **EVA/RMS Virtual Reality Simulation Trainer** is a real-time, crew-in-the-loop, virtual-reality simulation facility for flight crew training for integrated EVA/RMS/SSRMS operations and EVA support activities. This facility is the only such that is capable of providing an integrated environment for simultaneous EVA, RMS and SSRMS operations.

Several crewed-vacuum and thermal-vacuum chambers provide astronaut training and certification of EVA flight hardware. These chambers complement the Thermal-Vacuum Test Complex.

The **Space Station Airlock Test Facility** produces a vacuum environment in which to expose EVA equipment and human-occupied spacesuits. The facility has two chambers with two closed-life-support systems that enable shirtsleeve operations at reduced pressure and simulate high altitude. The pressure can be reduced to simulate the vacuum of space. EVA crews are trained in the operations of the ISS airlock and their spacesuits in the Space Station Airlock Test Article.

The **Shuttle Environmental Control and Life Support System Test Article** and the **Shuttle Airlock Test Article** are test complexes that have the interior geometrical configuration of the Shuttle cabin with an airlock attached to the cabin pressure bulkhead. The complexes are primarily used for Shuttle EVA crewmember training and testing of humans in a reduced-pressure environment.

The **Eleven-Foot Chamber** is a spacesuit development and certification test complex that has the features of a treadmill, crew weight relief and the necessary support systems for reduced pressure crew operations. During the vacuum portion of training, the crew spacesuits (also known as extravehicular activity mobility units (EMUs)) are given a final readiness check. Upgrades and recertifications of spacesuits are first tested without humans in the **Eight-Foot Chamber** before they are tested with humans in the Eleven-Foot Chamber. Each spacesuit receives a vigorous, six-hour treadmill workout in vacuum conditions to demonstrate its ability to handle the actual metabolic loads of a typical EVA.

The **Two-Foot Thermal-Vacuum Spacesuit Boot/Glove Test Chamber** provides an environment for evaluating spacesuit boots and gloves. It can also be used to provide profiles of outgassing, water boil-off and leaks for future prototype boot and glove systems. The new Dual Glovebox Chamber represents a substantial upgrade to the previous capabilities of the Two-Foot Chamber. Where previously the function of only a single EMU glove could be tested, now two gloves can be tested simultaneously. This two-handed access to the vacuum chamber allows for evaluation and certification of small EVA hand tools at thermal-

Astronaut Franklin R. Chang-Diaz, STS-111 mission specialist, uses specialized gear in the virtual reality lab at JSC to train for his duties aboard the Space Shuttle *Endeavour*. This type of virtual reality training allows the astronauts to wear a helmet and special gloves while looking at computer displays simulating actual movements around the various locations on the International Space Station hardware with which they will be working.

vacuum conditions for considerably less effort, cost and time.

JSC also has facilities for ground crews who support the flight crews before, during and after space flight. These facilities allow the ground crews to monitor space vehicle systems, to develop procedures used for flight, to train for these activities and to document data developed during flight. Descriptions of these facilities follow.

Since 1965, JSC's **Mission Control Center** has been the nerve center for America's human space flights. When ISS assembly began in 1998, the Center became a focal point for human space flight worldwide. The teams who work in Mission Control, Houston, as it is most widely known, have been vital to every U.S. human space flight since the Gemini IV mission in 1965, including the Apollo missions that took humans to the Moon and the 113 Space Shuttle flights since 1981.

Now with a permanent human presence aboard the ISS, flight control teams of experienced engineers and technicians are on duty 24 hours a day, 365 days a year, monitoring spacecraft systems and activities. Flight controllers keep a constant watch on crew activities and monitor the spacecraft's performance, as well as checking and rechecking all data to ensure operations proceed as planned. These highly trained flight controllers have the skills needed to closely monitor and maintain increasingly more complex missions.

The expanded Mission Control Center at JSC includes the Space Shuttle Flight Control Room, the ISS Flight Control Room, a Training Flight Control Room used to practice simulated space flight, a Life Sciences Control Room used to oversee various experiments, and the historic Apollo Flight Control Room—which has been preserved and designated a national historical landmark. Upgraded in the mid 1990s, the newest generation of control rooms is designed with commercially available computer workstations similar to those used in many modern offices. Today, the Shuttle Flight Control Room is staffed by up to 20 flight controllers when in operation, and the ISS Flight Control Room is staffed by up to 12 flight controllers at all times. These "front rooms," as they are called, are supported by hundreds of more experts working in back rooms located around the perimeter of the main control rooms.

Electrical Power Systems Laboratory provides the capability to test the Orbiter electrical power distribution and control subsystem using a high-fidelity replica.

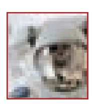
The **Intelligent Systems Laboratory and Software Technology Laboratory** support integrated vehicle-level systems executive and command and control software systems; real-time intelligent monitoring and diagnostic software systems; intelligent systems health and emergency management software systems; intelligent human/machine interfaces and intelligent mission, system procedure; and data analysis software systems and tools.

The **Integrated Planning System and Flight Data File Production Facility** is a robust platform for mission planning software tools and planning data. The IPS supports applications such as crew schedules on orbit, flight design and dynamics planning and assessment, and mission-specific robotics analysis for Shuttle and ISS. For ISS, the IPS also supports resource utilization planning, procedures development and control, and integrated command and telemetry reconfiguration. The Flight Data File Production Facility produces all procedures, cue cards and other references used by the astronauts during Shuttle and ISS missions and during training. Specialized paper copies of flight data files are prepared for crew use during space flight in the Flight Data File Production Facility.

Bioastronautics, Space Science and Astromaterials

In addition to human spacecraft design, development and operations, JSC conducts revolutionary research in the areas of bioastronautics, space science and astromaterials.

The facilities and laboratories that support this research are described below.



Bioastronautics, Space Science and Astromaterials Facilities

- Graphics Research and Analysis Facility
- Anthropometric and Biomechanics Facility
- Microbiology Laboratory
- Usability Testing and Analysis Facility
- Space Radiation Analysis Group Radiation Operations Support Area
- Water and Food Analysis Lab
- Pharmacology Laboratory
- Nutritional Biochemistry Laboratory
- Lighting Environment Test Facility
- Test Subject Facility
- Bone and Mineral Laboratory
- Human Research Facility

The **Graphics Research and Analysis Facility (GRAF)** uses high-performance computer graphics workstations to address human engineering issues in spacecraft design and analysis. The GRAF enables human modeling, viewing analysis, animation development, lighting evaluation, crew operations and maintenance analysis, design concepts visualization, and virtual-reality applications.

The **Anthropometric and Biomechanics Facility (ABF)** is used to research and evaluate flight equipment, procedures and systems from the perspective of biomechanics, human performance and ergonomics. For example, ABF personnel have tested and evaluated crew work procedures and equipment, spacesuit design, EVA and intravehicular activity (IVA) human performance issues, EVA/IVA tool design, and EVA/IVA crew-induced loads. Data gathered by the ABF are used to improve crew living and working conditions to enhance productivity and operational efficiency.

The **Microbiology Laboratory** is a level-two facility that is responsible for addressing crew health and environmental performance issues related to microbial infection and contamination. In this facility, staff scientists and visiting researchers conduct operational monitoring and investigative research using classical microbiological, advanced molecular and immunohistochemical techniques. They also investigate the effects of space flight on both crew health and the microbial ecology of the spacecraft.

The **Usability Testing and Analysis Facility (UTAF)** provides analysis, evaluation and usability testing of crew interfaces for work areas and equipment. It has a unique capability with a staff experienced in the rigors of both cognitive human factors and ergonomic research and evaluations. While the UTAF can act as a stand-alone facility, it is integrated with other facilities, such as the ABF and the GRAF.

The **Space Radiation Analysis Group Radiation Operations Support Area** describes, models and monitors the radiation environment; recommends methods to mitigate the adverse effects of radiation; and is a key component of the operational radiation health plan for all U.S. space flights. The goal of NASA's Radiation Health Program is to achieve human exploration of space without exceeding acceptable risk from exposure to ionizing radiation.

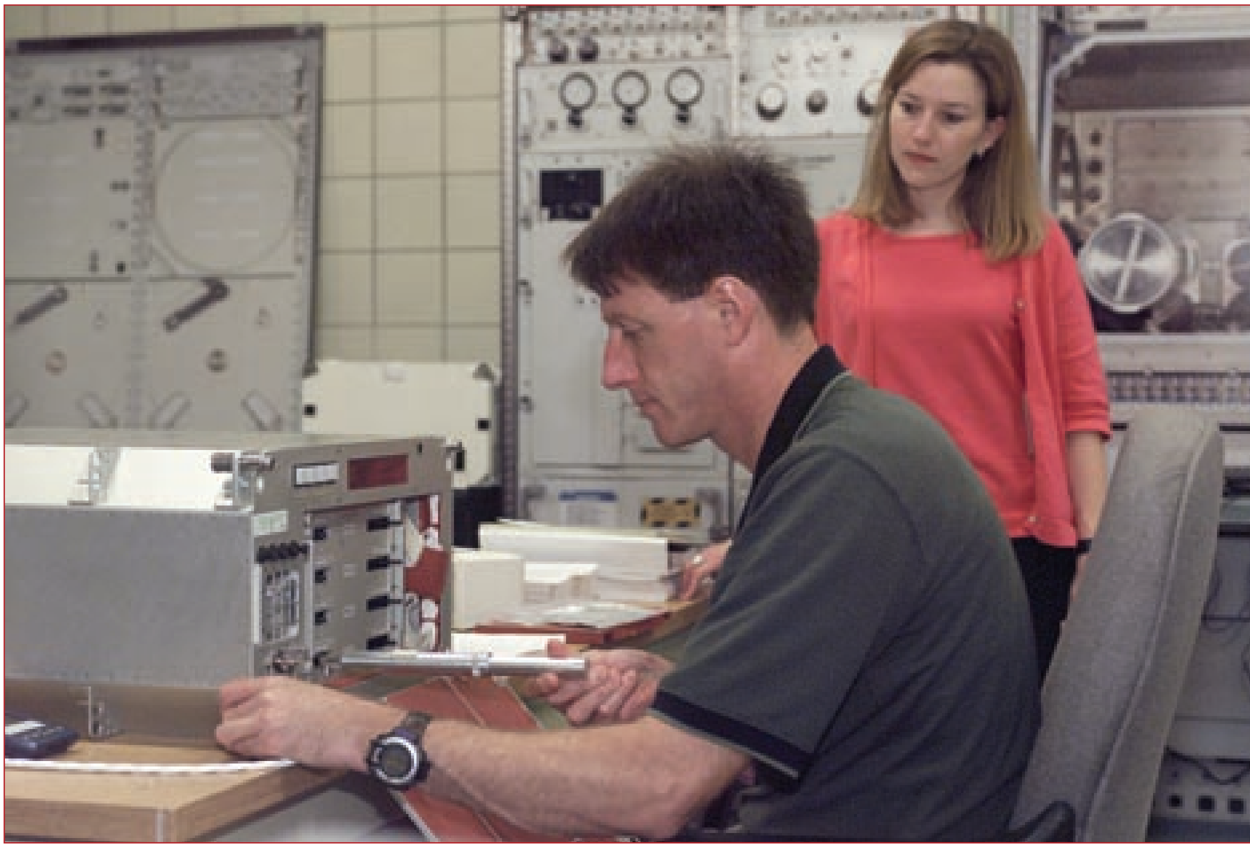
The **Water and Food Analysis Lab (WAFL)** is responsible for preflight and postflight analyses of Shuttle water for biocides, organics and metals, and the postflight analyses of samples of Shuttle water transferred to the ISS in contingency water containers. The lab supports in-flight use of the total organic carbon analyzer on the ISS and performs analysis of water samples returned from various ports of the ISS water recovery system. The WAFL assists in troubleshooting the cause of off-nominal findings, conducting studies of the sources of water pollutants, establishing and promulgating requirements for water quality, and performing limited nutritional analysis of food to be used in flight.

The **Pharmacology Laboratory** supports medical requirements for the Shuttle, ISS and space exploration programs. Activities conducted in this lab include clinical pharmacy services, pharmacokinetics and pharmacodynamics research, therapeutic drug monitoring, specialized therapeutic monitoring for space flight-related pathophysiology, novel dosage form development and pharmaceutical stability assessment.

The **Nutritional Biochemistry Laboratory** supports operational assessment of crewmember nutritional status as well as ground-based and flight research projects. The laboratory supports studies of the effects of space flight on energy and nutrient metabolism, body composition, erythropoiesis, fluid and electrolyte homeostasis and the human musculoskeletal system. Dietary intake, body composition, protein, bone, iron, mineral, vitamin and antioxidant status are measured in participating crewmembers.

The **Lighting Environment Test Facility (LETF)** investigates and evaluates proposed lighting systems for use on space vehicles to enhance the crews' direct and indirect viewing. This effort includes the investigation, measurement and analysis of artificial lighting systems such as docking lights, portable lights and navigation lights. In addition, studies conducted in the LETF include analyses in the reflective characteristics of various materials and the effects of solar lighting; transmission characteristics of transparent materials used for visors, displays and windows; and camera performance for minimum and maximum illumination.

The **Test Subject Facility** provides an ideal environment in which to test and evaluate space hardware and experimental procedures before launch. Evaluating selected countermeasures to space adaptation, testing medical devices and equipment, and training for microgravity exposure all benefit from the ability to simulate microgravity without leaving Earth's atmosphere. The KC-135, NASA's modified 707 aircraft, flies parabolic arcs to produce episodes of weightlessness lasting from 20 to 25 seconds.



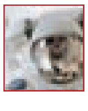
Astronaut C. Michael Foale, Expedition Eight mission commander, participates in a High Density Protein Crystal Growth payload training session in the Space Vehicle Mockup Facility at JSC.

A typical flight lasts from two to three hours and consists of 30 to 40 parabolas. The KC-135 can also provide short periods of lunar and martian gravity. Over the last 35 years, approximately 100,000 parabolas have been flown in support of the Mercury, Gemini, Apollo, Skylab, Space Shuttle and International Space Station Programs.

The **Bone and Mineral Laboratory** conducts ground-based and in-flight research to determine the effects of real or simulated space flight on the musculoskeletal system and to develop countermeasures to these effects. Changes in bone mineral density and quality are measured, as well as decreases in muscle volume and changes in the size and composition of intervertebral discs. State-of-the-art equipment and techniques are used in this laboratory, including bone densitometry, magnetic resonance imaging and ultrasound/acoustic assessment of bone quality.

The **Human Research Facility (HRF)** is a complement of hardware and science experiments designed to document and develop countermeasures for the effects of long-duration space flight on crewmembers.

Astronaut Edward T. Lu, Expedition Seven flight engineer, participates in Human Research Facility training in the International Space Station Destiny laboratory mockup/trainer at JSC's Space Vehicle Mockup Facility.



4 Capabilities for the Future: JSC Products and Services

4 Capabilities for the Future: JSC Products and Services

JSC's Guiding Principles

PROFESSIONAL EXCELLENCE: We are dedicated to the achievement of professional and technical excellence through our knowledge, discipline and timeliness and the high quality of our work. We perform our work accurately and safely.

INTEGRITY: We conduct ourselves with honor, continuously exhibiting honesty and truthfulness in all our actions. Developing an environment of trust and adhering to ethical behavior are critical to our success.

RESPECT: We respect each other, our counterparts and ourselves. From that respect comes regard and consideration for others.

COMMITMENT: This is the glue that binds our values together. It comes from our loyalty to each other and from our passion toward our endeavors. Commitment gives us the courage to perform our duty to do the right thing.

The STS-112 crewmembers inspect flight hardware during a crew equipment bench review in an off-site facility near the Johnson Space Center. From the left are Astronaut Sandra H. Magnus; Cosmonaut Fyodor N. Yurchikhin; Astronauts Pamela A. Melroy; Piers J. Sellers; Jeffrey S. Ashby; and David A. Wolf. Yurchikhin represents Rosaviakosmos, the Russian space agency.

JSC Goals and Strategic Alignment 4.1

JSC has established a set of goals for the Center that directly aligns with the NASA vision, mission, goals and implementing strategies. The JSC goals, and their alignment to the NASA goals, are described further in the Annual Plan, included as an insert to this document. In addition, the JSC Center Director Metrics are direct performance measures of the JSC goals that accurately portray the Center's performance in support of the Themes and Enterprises.

This chapter will describe JSC's unique capabilities, and the products and services that JSC provides to the Themes and Enterprises in much greater detail.

Human Spacecraft Design and Development 4.2

JSC provides to its customers human spacecraft design and development products and services, including project management and subsystem engineering; government-furnished equipment (GFE) and flight crew hardware development and maintenance; robotics technology; software development and implementation; safety and mission assurance; hazardous materials testing; rocket propulsion testing; advanced space propulsion; and support to the OSP. Each of these products and services is described in more detail below.

Project Management and Subsystem Engineering 4.2.1

JSC's dedicated team of scientists, engineers and technicians has managed the design, development and testing of all U.S. human spacecraft—from the Gemini spacecraft to the U.S. segment of the ISS. The task of turning the visions of design engineers into the realities of a functional, orbiting spacecraft capable of supporting human life is a monumental one. With Mercury, Gemini, Apollo, Skylab, Shuttle and now the ISS, NASA continues to accomplish this task.

The success of these programs can be attributed to the Center's broad depth of subsystem engineering expertise that encompasses all functions related to

Johnson Space Center personnel meet to discuss changes to the site that will contribute to enhancing our future capabilities.

human spacecraft. These functions are:

- Life support systems.
- Power systems.
- Crew equipment.
- Guidance, navigation and control.
- Electrical power generation and distribution.
- Cooling systems.
- Structures.
- Flight software.
- Robotics.
- Spacesuits and EVA equipment.

The JSC team uses project management and systems engineering expertise to integrate these subsystems into functional spacecraft.

Project Management

JSC provides expertise in engineering design, development, analysis and test support, as well as system and subsystem expertise to the Space Shuttle, ISS, OSP, EVA, bioastronautics and advanced human exploration programs. JSC provides NASA programs with GFE, including hardware and software; the design, development, manufacture and testing of flight-related hardware; flight system and subsystem expertise; engineering analysis and test services; and mission planning and analysis for advanced human exploration missions.

JSC provides top-level planning, training and review of all human space flight projects and services, including GFE projects, project management processes and project management tools and training. Through these processes, JSC is able to ensure compliance with project management process requirements, configuration management requirements and engineering standards, as well as the certification and safety of flight projects.

JSC has developed processes to ensure standardization across flight projects. These include:

- Project approval and implementation procedures.
- Project management of GFE projects.
- Use of off-the-shelf hardware.
- In-flight hardware development.
- Use of off-the-shelf software in flight projects.
- Flight readiness assessment.

A long-term goal of the Center is to further develop concurrent engineering capabilities, as well as common processes and standards. This goal includes improved project coordination involving appropriate technical disciplines and tools such as the Design Data Management System. In addition, an office has been chartered to monitor both technical and business project development activities in the areas of process compliance and improvements.

Subsystem Engineering

JSC provides engineering expertise in technical disciplines such as:

- Guidance, navigation and control.
- Electrical power generation, storage and distribution.
- Other avionics systems, including data management, display and control.
- Instrumentation.
- Telemetry and communications.
- Structures and materials.
- Thermal protection and control.
- Mechanical systems.
- Propulsion, fluid management and pyrotechnics.
- Environmental control and life support.
- Spacesuits and EVA equipment.
- Aerodynamics, aerothermodynamics and aeroelasticity.
- Flight software.
- Mission planning and analysis.
- Robotics and advanced automation systems.
- Biomedical systems.
- Overall systems engineering and simulation.

Subsystem experts provide analyses to major program boards, as well as guidance and oversight for problem-resolution teams. Subsystem engineering expertise is also provided for flight readiness reviews and mission operations.

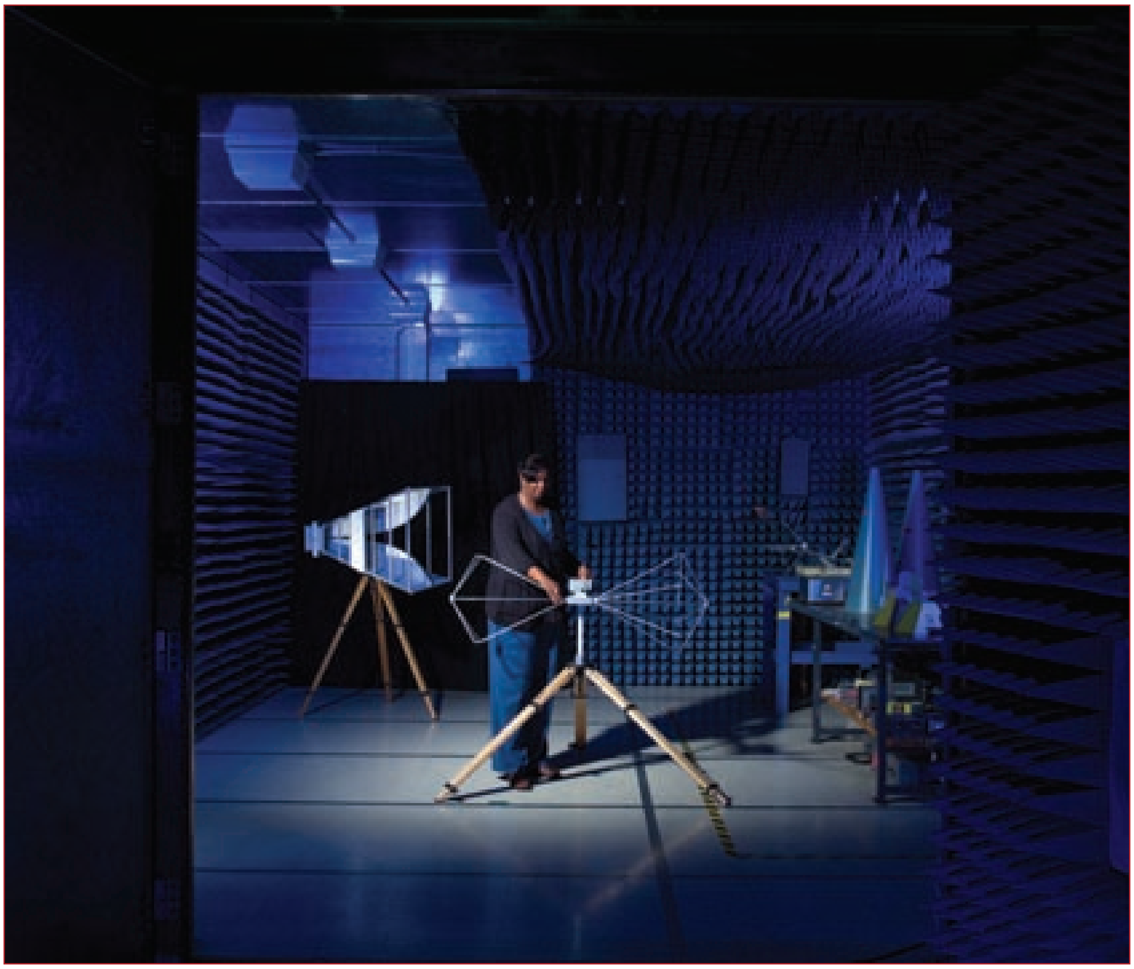
GFE Hardware and Flight Crew Hardware Development and Maintenance 4.2.2

JSC supports the Shuttle and ISS Programs in a variety of hardware development projects and sustaining engineering activities. These activities include, but are not limited to:

- Space integrated global positioning system/inertial navigation systems.
- Space-to-space communications.
- Robotic bird's-eye view software.
- Water transfer equipment.
- Electrical power.
- Video and still cameras.
- Wireless video equipment.
- Laptop computers.
- Biomedical projects.
- Flight crew items.

Representative Examples of JSC's GFE

1. JSC supplies crew health care system equipment for the ISS. This equipment provides countermeasures as well as health and environmental monitoring equipment. The hardware provides the capability for crewmembers to maintain their physical fitness, to monitor their health and to provide rehabilitation or medication as required, as well as to provide measurements of the environment in the ISS. This hardware and associated software is critical to the continued well-being of the ISS crew, which is a key factor in maintaining the ISS and performing useful science in space.
2. The fluid line repair kit consists of a set of tools required for permanent repairs of damaged fluid lines on the ISS. These tools include a tube cutter to remove a damaged fluid line, a smart seal, which creates a seal for the replacement fluid line section, and a tube marker to mark the correct insertion depth for the smart seal.
3. Space integrated global positioning system/inertial navigation system (SIGI) uses signals from the global positioning system (GPS) constellation of satellites orbiting the Earth to compute the position, velocity and orientation of the ISS. Because the ISS has four GPS antennas, the SIGI can compute the ISS orientation by calculating the timing differences between when identical GPS signals reach each of the four antenna locations. The position, velocity and orientation data from the SIGI are used by the control system of the ISS to keep the ISS correctly pointed and positioned in orbit.
4. The Orbiter aft fuselage gas sampling system collects samples of the atmosphere in the Orbiter's aft fuselage during ascent to determine whether any hazardous gases were present by postflight analysis of the samples.
5. Due to the highly critical nature of most ISS robotics tasks, a need was identified for some form of trainer that the crew could use to maintain proficiency between operations. The Robotics On-Board Trainer (ROBOT) project is intended to provide this training capability by using as much existing hardware and software as possible.
6. The manual electrical cable tester is a time domain reflectometer cable tester for the ISS to detect and locate electrical short and open circuit faults along nonenergized, multi-segment cables. It will initially be used to detect faults in primary and secondary ISS power cables.



JSC scientist performing an electromagnetic interference experiment in the Building 14 Thermal EMI Chamber.

A training capability for GFE project development is currently being developed to enhance the ability and efficiencies among resources. In addition to the personnel required to execute the project, unique facilities are required to manufacture and test GFE developments. Some of these capabilities include vibration stands and thermal and EMI chambers. These facilities, which are required to verify hardware characteristics in the various space flight environments, are described in more detail in Chapter 3.

JSC also provides sustaining engineering and maintenance for the hardware that it developed. JSC is exploring more efficient ways of using personnel to perform critical program functions, as well as maintaining hardware data certification status. A working group is currently reviewing sustaining engineering activities for improvement.

Robotics Technology 4.2.3

JSC manages and conducts comprehensive, world-class robotics and automation programs required to support current and future missions of NASA's human space flight activities. These responsibilities encompass defining requirements; and analyzing, designing, developing, integrating, testing, verifying and operationally supporting current and advanced software tools, applications and systems, and hardware components and systems in the areas of telerobotics and autonomous robotics systems for ground and space flight applications.

Current Advanced Robotics Technology Projects

1. **Robonaut** – A highly dexterous humanoid robotic torso designed to support space assembly and maintenance activities. Robonaut is capable of handling tools and working with the same infrastructure as crewmembers and handling EVA tools designed for crewmembers.

2. **Mini-AERCam** – A prototype free-flying inspection camera that can be used in either an autonomous or a tele-operated mode to capture images from any point in space around a vehicle. It can be used for a wide variety of purposes, from inspecting Shuttle tiles to providing remote sensors for ISS solar arrays.

3. **EVA Robotic Assistant** – A mobile robotics platform that is being used to develop enhanced human/robot interface protocols and communication techniques for a wide variety of human exploration activities.

In addition to developing these technologies, the Center advocates infusing advanced robotics into future space missions, sharing technology with other NASA field centers, working with universities and developing joint projects with other federal agencies. JSC maintains unique, state-of-the-art facilities to develop these advanced robotic systems.

Over the next few years, the Center plans to continue enhancing the core technology base used to develop advanced robotic systems. Particular emphasis will be given to improving autonomous capabilities for robots, as well as to testing new ways for humans and robots to work together on complex problems, including those problems associated with space assembly and maintenance.

Software Development and Implementation 4.2.4

JSC has established a Software Engineering Process Group (SEPG) to maintain and improve the software development processes and the tools that support them. The SEPG has been using the Software Engineering Institute's Capability Maturity Model (CMM) for software to improve software development capability and maturity. A pilot effort is in progress to evaluate the software CMM for application to flight software.

JSC provides software applications development and support services to the human space flight programs for the development and sustaining engineering of Internet-based application systems. Software and information management technologies and approaches continue to trend toward centralization of Internet management resources. JSC's goal is to maintain a consistent Internet application infrastructure that can leverage technologies that emphasize customer-managed development and the use of portal approaches for distributing content management responsibility to content owners. JSC implements this philosophy by requiring that a standards-based development methodology, CMM Level 3, be used, which ensures quality and consistency across development projects. JSC also requires adopting tools and techniques that facilitate the use of this approach.

Robonaut, one of the advanced robotics programs for which JSC is responsible.

Representative Examples of Software Products

1. **Space integrated GPS/SIGI attitude firmware** – JSC has initiated an update to the commercial off-the-shelf SIGI attitude firmware code to eliminate known problems with the existing code, to make the code more modular and maintainable for the life of the ISS and to document the algorithms used in the code, allowing users of the SIGI to understand its theoretical basis. The software has a planned release date of December 2003. It will undergo unit testing, code inspection and embedded testing. Prior to final release, the firmware will be tested. Once functional qualification testing is completed, the firmware will be loaded into the SIGIs on orbit.
2. **Advanced Resistive Exercise Device (ARED)** – ARED provides the ISS crew the ability to counteract the effects of microgravity by performing many exercises available in Earth-based gyms. The ARED software provides a means for doctors on the ground to specify exercise regimens for the crew and to transmit information related to the regimens to the crew on orbit. It also collects data from numerous sensors during exercise to provide feedback to the crewmember and for later analysis by ground-based doctors.
3. **The Dynamic Onboard Ubiquitous Graphics (DOUG)** – The DOUG application is quickly becoming the primary 3-dimensional graphical viewing tool at JSC, as well as on board the Space Shuttle and the ISS. DOUG is the follow-on product to the Display Software Package (DSP) that is installed in all of the major training facilities at JSC. DOUG extends DSP by increasing the number of platforms on which the software will run and by introducing a common user interface. DOUG is now used for ground simulation scene displays and is also flown on board the Space Shuttle and the ISS. It is used for a situational-awareness tool during robotic operations, an EVA-planning tool for EVA task reviews, an SSRMS training simulator and a Simplified Aid For EVA Rescue (SAFER) flight simulator.

Moreover, JSC provides tailored capabilities to develop and sustain ground software for human space flight operations. JSC software capabilities in human space flight operations include flight software and crew interface requirements, design and assessment. Capabilities for delegated programmatic functions include the development and control of flight software requirements and flight software testing support. Development and evaluation of future facility and crew interface software technologies and designs are provided in a rapid prototyping laboratory.

Safety and Mission Assurance Products 4.2.5

The mission of JSC is to assure successful space flight and to promote a safe and healthy work environment. The Center reduces risk by providing technical evaluations, assessments and analytical services throughout the life cycle of NASA programs and projects.

JSC also provides qualitative and quantitative risk assessments of proposed changes and technical evaluations for design reviews, systems certification and

Safety and Mission Assurance Products and Services that JSC Provides to the Programs

1. **Safety Engineering** – The application of the systematic, forward-looking identification and control of hazards throughout the life cycle of an activity, a system, a function, a project or a program.

2. **Reliability, Availability, Maintainability and Supportability** – Assessment of inherent system design features that include establishing reliability requirements; selecting measures for design definition and review; performing quantitative and qualitative reliability analyses and assessments to verify design characteristics, testing and certifying the design; identifying limited-life items; and participating in problem resolution and recurrence control.

3. **Quality Engineering** – Evaluation of the design, manufacturing, testing and refurbishment of space flight hardware and software to ensure delivery of products in accordance with functional, performance and design requirements.

4. **Quality Assurance** – Inspection and surveillance activities performed during production, testing and operations to reduce the overall risk to a project's cost, schedule and mission success.

5. **Software Assurance** – Assessment of software to determine whether it meets quality, reliability and safety requirements, as well as technical and performance requirements.

6. **Risk Management** – Assessments of and recommendations for a disciplined and documented approach to ensure risk is identified, evaluated, managed and mitigated throughout the life cycle.

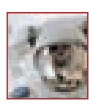
7. **Technology Assurance** – Analysis and evaluation of a broad range of new and emerging tools, techniques and processes to complement long-range projects and programs.

8. **JSC Analysis and Testing Laboratory** – Risk to technical, cost and schedule performance can be reduced through acquiring timely, reliable performance data and providing required NASA Standards workmanship training and schedule performance.

9. **Independent Assessments** – Identification and assessments are provided for technical and programmatic issues, including observations and recommendations.

Additional products that are provided in support of programs include:

- Probabilistic Risk Assessments, including both tools and methodologies.
- Trade studies.
- Commit-to-flight statements.
- Root cause and corrective action investigations.



risk documentation baselines. Real-time mission support on ascent, orbit and entry is provided for operational risk assessments.

The Center provides safety and mission assurance resources to all human space flight programs, including the Space Shuttle, the ISS and the OSP, by providing risk assessment expertise on the following teams:

- Reliability and Maintainability Panel
- Computer Safety Working Group
- Safety Review Panel
- Safety and Mission Assurance Panel
- Quality Assurance Panel
- Safety Working Group
- Software Assurance Panel

Products provided to these teams include risk assessments, safety analyses, design specifications, failure modes and effects analyses/critical items lists, hazard analysis, noncompliances and verifications.

WSTF conducts test of hazardous materials.

Over the next several years, JSC plans to expand its capabilities for probabilistic risk assessment, reliability and safety analysis support. JSC plans to use and have available for use the latest risk assessment tools and methodology for performing safety and mission assurance analyses for hardware and software. Other initiatives include creating a new, better-integrated Preventive and Corrective Action system; continuing to realign, train and hire to meet the needs of the programs; reinvigorating the lessons learned database; and integrating the ISS's International Partners into real-time operations.

Hazardous Materials Testing 4.2.6

WSTF offers extensive capabilities for testing of hazardous materials. The hazardous materials that are tested at WSTF are primarily propellants, including oxygen, hydrogen, unsymmetrical dimethylhydrazine, monomethylhydrazine, hydrazine, nitrogen tetroxide and green or nontoxic propellants such as hydrogen peroxide, ethanol and hydrocarbons. Also included are other hazardous materials used on spacecraft, including refrigerants and heat exchange fluids. Testing is performed to determine the nature and extent of hazards.

The degree of hazards ranges from long-term compatibility and corrosion, to susceptibility, to ignition, to high-energy release reactions that lead to combustion, explosions and detonation. WSTF capabilities also include determination of hazards resulting from high potential energy release situations including high or low temperature and pressure and hypervelocity impact.

WSTF uses the extensive information and test results generated by the testing to provide hazards evaluation of components and systems planned for containment and of the hazardous material. Additional services include the preparation and dissemination of handbooks and manuals on the fire, explosion, compatibility and safety of the hazardous materials, as well as the development and presentation of safety courses on the hazardous materials.

Other federal agencies – such as the U.S. Air Force, U.S. Navy and Department of Energy – and private industry have access to and are using WSTF capabilities and services through reimbursable agreements and funding. WSTF is routinely used by a number of federal agencies and private companies to provide safe disposal of propellant fuels and oxidizers. It is also used as a component and soft goods field decontamination site.

Rocket Propulsion Test Program Support 4.2.7

JSC currently supports propulsion test capabilities for the Shuttle and ISS programs, as well as potential future human exploration missions that require attitude control systems or planetary surface propulsion. The Center's testing capabilities encompass nontoxic gases and liquids; thruster operation and performance in ambient and simulated thermal environments; thruster operation and performance in vacuum environments; propellant storage and feed system characterization; and integrated systems.

WSTF provides a unique hardware component test capability for a number of different programs. For example, the Space Shuttle auxiliary power unit (APU) gas generation valve module and the APU fuel tank fleet leader test systems are operated at WSTF. These tests may include system-level development and qualification tests. Similarly, ground support equipment development and validation also occurs at WSTF. Finally, in 1992 WSTF established a depot refurbishment and repair capability for most of the Shuttle orbital maneuvering system and reaction control systems.

Advanced Space Propulsion Laboratory 4.2.8

The Advanced Space Propulsion Laboratory (ASPL), located at the Sonny Carter Training Facility at Ellington Field in Houston, Texas, conducts research into advanced plasma rocket technology and other aspects of advanced propulsion for future human and robotic missions. ASPL operates a prototype rocket engine that is a demonstration of a variable specific impulse magnetoplasma rocket (VASIMR).

Long travel times and small payloads have historically been major concerns and drawbacks when using conventional rockets in space flight.

Rocket Propulsion Test Facilities and Unique Capabilities

- Shuttle ascent/descent pressure profile and corona test simulation
- Space and Mars surface pressure/temperature simulation
- Low-thrust cold/warm gas thruster measurement
- Gaseous propellant storage and distribution
- Cryogenic propellant liquefaction, storage and distribution
- Remote test cells and chambers designed for hazardous operations
- Clean room and oxygen cleaning
- Pneumatic and hydraulic pressure certification testing

Planned enhancements to the JSC propulsion testing capabilities that are planned include:

- Incorporating low-thrust measurement under vacuum conditions for water-based thrusters.
- The ability to test low-thrust gaseous oxygen/hydrogen and oxygen/methane thrusters.
- Incorporating simulated lunar surface pressure/temperature for hazardous component and system testing.
- The ability to test integrated water-based systems involving electrolysis-fuel cell power, mission elapsed time-water thrusters, and oxygen/hydrogen thrusters for the ISS and any future human spacecraft or cargo resupply vehicles.

The VASIMR engine is not powered by chemical reactions, as conventional rocket engines are, but by electrical energy that heats a propellant. That propellant is plasma, a gas that reaches extreme temperatures. This new technology, which is powered by nuclear-generated electricity, could dramatically shorten human transit time between planets. The VASIMR will also be able to propel robotic cargo missions with very large payloads.

VASIMR has recently been awarded a U.S. technology patent. Future planning includes a possible flight demonstration project beginning in 2005. Additional activities in partnership with other federal agencies are in development.

Orbital Space Plane Program Support 4.2.9

The Aerospace Technology Enterprise manages the OSP Program. The OSP will be used to provide a transportation system for the ISS crew. It will also provide an ISS crew rescue capability, accommodating astronauts who are deconditioned due to long-duration missions or who may be ill or injured.

JSC provides expertise in support of the design and development of the OSP spacecraft, as well as integration of the OSP with the ISS and the development of the OSP flight and mission operations capabilities. JSC provides the flight operations subsystem expertise for the X-37 program, as well as the core NASA operations team for the X-37. This team will continue to follow development of the atmospheric drop vehicle, and will aid in development of flight- and ground-test procedures leading up to the first test flight. JSC also provides expertise to lead OSP study efforts. These studies are integral to the development of the OSP and to technology trades that will be made now and in the future.

JSC is also responsible for managing the Pad Abort Demonstrator (PAD) project. JSC provides engineering support to the PAD project by providing expertise in systems engineering and integration, as well as ground systems and parachute subsystem management. This management support includes development of flight test objectives, integration of subsystems into the PAD test article and development of flight- and ground-test procedures and policies.

Human Operations in Space 4.3

At JSC, human operations in space encompasses crew selection and training; aircraft operations and training; mission planning, training and operations; and EVA planning, training and operations. Each of these services is below.

Crew Selection and Training 4.3.1

JSC is home to the nation's Astronaut Corps and is responsible for preparing explorers from both the U.S. and our International Partner nations for the demands of living and working in space. Approximately 105 men and women with scientific, military and education backgrounds make up NASA's active Astronaut Corps, with another 35 experienced astronauts in leadership positions throughout JSC and the Agency.

JSC supports the Space Shuttle and the ISS programs with flight crews that have been carefully selected and trained to optimize the success of each mission. A diverse corps of astronauts is essential for providing flexibility to all the NASA Enterprises and to ensure a broad scope of expertise. In addition to mission operations support, the Astronaut Corps is also invaluable for providing the crew perspective to development and testing activities, advanced programs and NASA outreach efforts.

At the Center, potential astronaut candidates undergo one of the world's most competitive selection processes. Astronaut candidates spend up to two years completing classroom training and specialized mission training before they become eligible for a flight assignment. During their classroom training, candidates are schooled in Space Shuttle and ISS systems along with a variety of other disciplines, including Earth sciences, meteorology, space science and engineering. They also train in land and water survival, aircraft operations and scuba diving to prepare for underwater spacewalk training.

Once astronaut candidates have completed their training period, they are given their mission assignments and are grouped with experienced astronauts to continue training. The two types of astronauts, pilots and mission specialists, perform different functions. Pilot astronauts are assigned as pilots and, possibly, eventually as mission commanders; and mission specialists conduct spacewalks, perform robotics tasks, engage in scientific research and act as flight engineers during launch and landing.

Ensuring crews are well prepared will continue to be a challenge for the coming years. JSC has plans to modify the astronaut curriculum to accommodate the multinational and long-duration aspects of NASA's evolving programs.

Aircraft Operations and Training 4.3.2

JSC manages a variety of aircraft that are essential for flight crew readiness training. These aircraft include the Shuttle Training Aircraft, NASA's T-38 space flight readiness trainers and the KC-135 Microgravity Research Aircraft. Additionally, the Center operates and maintains other aircraft that are extensively involved in scientific research and technology development, including the WB-57 High Altitude Research Aircraft. Other aircraft include the Shuttle Carrier Aircraft, which is a modified Boeing 747 designed to ferry the Space Shuttle Orbiters; the Super Guppy over-sized cargo aircraft, which is designed to transport large hardware; and the mission-management support aircraft.

Pilot astronauts train in a Gulfstream jet aircraft that has been specially modified to simulate the approach and landing of the Space Shuttle. Because the Shuttle lands at much higher speeds and at an incline about seven times steeper than that of a commercial airliner, this jet provides a uniquely intensive training experience that prepares astronauts for handling the Shuttle during landing. Pilots will fly more than 600 approaches in this aircraft before they land the Shuttle. All astronauts train in T-38 jets to learn and maintain flight techniques and cockpit management.

Additional support to Shuttle flights is provided by White Sands Space Harbor (WSSH). Located in the middle of the U.S. Army's White Sands Missile Range, WSSH operates and maintains three runways used extensively by the SSP. Approximately 90 percent of the Shuttle pilot approach training is conducted at WSSH. This facility has been used extensively to demonstrate the applicability of landing aids that are deployed at numerous landing sites around the world. In addition, its runways are maintained and supported for every Shuttle launch for a potential emergency landing there.

Mission Planning, Training and Operations 4.3.3

JSC provides singular human space flight operations expertise for:

- Mission design and activity planning.
- Flight crew and flight controller training.

Mission planning capabilities

- Payload requirements integration
- Trajectory analysis and design
- Flight planning and crew timeline scheduling
- Development, integration and verification of systems and integrated procedures, including those for spacewalk activities and robotics

Training Capabilities

- Training requirements and curricula definition
- Lesson development
- Simulation scripting and scenario development
- Training instruction

- Mission management.
- Flight execution.
- Operational facilities development and sustaining engineering.

Operations expertise is provided to vehicle design, as both in-line support and as a check-and-balance to ensure vehicle operability.

Real-time mission operations capabilities include the flight control team, with its leadership and integration capabilities, and the Mission Control Center. Together, these teams and the Mission Control Center provide a flexible and durable capability for simultaneous development and operator training, and for real-time command and control operations for multiple vehicles including dynamic phases, orbital operations and archiving.

As an operational capability to the ISS and Shuttle programs, JSC develops and controls flight techniques and flight rules. JSC engineers and technicians provide unique support to launch commit criteria evaluation, failure analysis, flight hardware testing, flight manifest evaluation, range safety coordination and integration of mission operations flight readiness reviews, including space communications readiness. Capabilities supportive of safety include analysis and assessment of flight systems and payloads operations safety, vehicle and flight software changes, test data and postflight data.

As new human space flight programs emerge from definition into development, JSC provides unique operations lessons learned from previous programs, trade studies between vehicle and ground requirements, operations requirements, design reference mission definition, operations concepts, ground systems architectures and crew interface design requirements.

Extravehicular Activity Planning, Training and Operations 4.3.4

JSC also provides EVA capability to perform on-orbit assembly, maintenance and repair for the ISS, the Shuttle and science payloads, such as the Hubble Space Telescope. JSC ensures the future of NASA's EVA capabilities and infrastructure that are needed to lead the next generation of human exploration beyond low Earth orbit. JSC provides an integrated approach to all aspects of EVA planning, training and execution, including the design, development, testing, certification, refurbishment, provisioning and logistics of all hardware necessary to support EVA on existing and future space missions.

Development plans in the next three years include an upgrade to the ISS on-orbit EVA system, such as the addition of numerous external payload attachment sites; the addition of rails for access to outboard truss segments on the ISS and the transition to sustaining engineering; and chamber test control system upgrades to improve reliability. At the Sonny Carter Training Facility, there are plans to upgrade the SSRMS to improve reliability and to add more mockups to improve training fidelity.

Additional hardware development plans for the crew's spacesuits, or EMUs, include the following hardware components:

- Enhanced caution and warning system
- Lithium ion battery
- Helmet bubble hard coat
- Disposable in-suit drink bag
- Biomedical cable harness redesign
- Replacement of hardware lost in the *Columbia* accident
- Battery discharge module switch command capability
- Seventy-five-foot safety tether
- Fan-pump-separator electronics redesign
- Water conditioning
- Secondary oxygen pack enhancements

JSC Provides Human Space Flight Programs with Extravehicular Activity

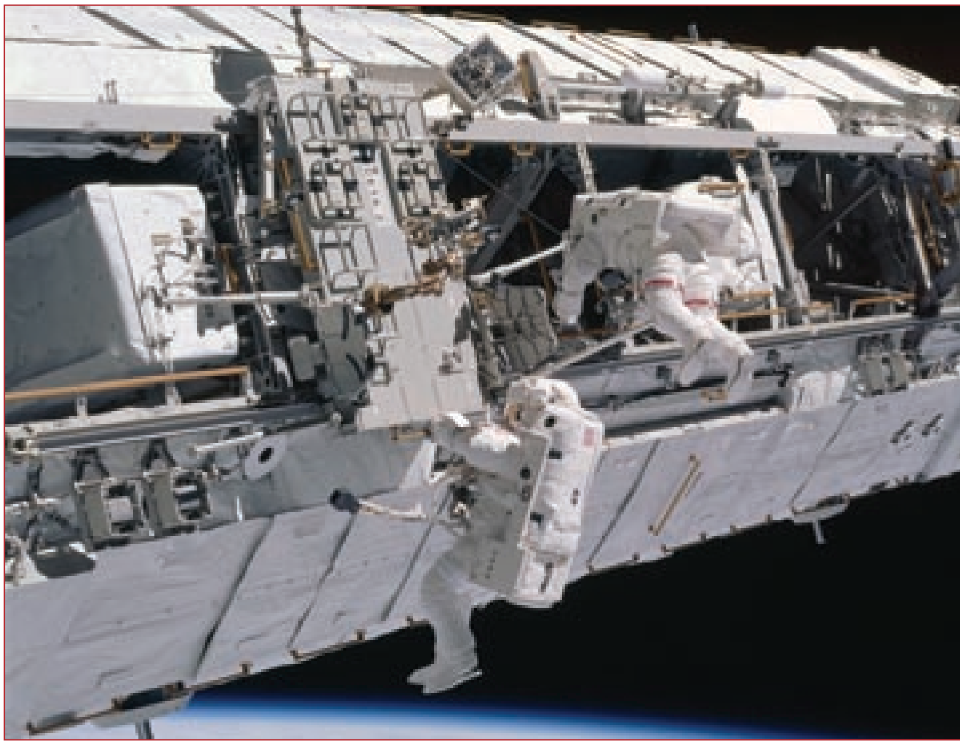
- Requirements definition and integration
- Tasks and logistics planning
- Hardware development, certification and provisioning
- System testing in vacuum and thermal vacuum chambers
- System testing and task training in zero-gravity (zero-G) conditions in neutral buoyancy and in environments with gravity conditions equal to Earth's gravity (1-G)

The EVA operations and training services and products include:

- Flight-to-flight processing and maintenance of EVA system hardware used to support Shuttle and ISS EVAs.
- Event-to-event processing and maintenance of EVA system hardware used for EVA training or EVA system testing in zero-G, neutral buoyancy and 1-G environments.
- Real-time mission support in the Mission Control Center, Increment Management Center and Mission Evaluation Room.
- ISS vehicle EVA hardware analysis, development testing, verification, operations support and sustaining engineering.

Finally, planned tool enhancements to augment the crew's capability to maintain and repair flight hardware in orbit include:

- Crew hooks enhancements.
- Pistol grip tool enhanced torque application capability.
- Orbital replacement unit temporary stow device.
- On-orbit quick disconnect trainer
- Extended life slide wire.



Astronauts John B. Herrington and Michael E. Lopez-Alegria, STS-113 mission specialists, work on the newly installed Port One truss on the International Space Station during one of the three scheduled sessions of extravehicular activity.

Bioastronautics, Space Science and Astromaterials 4.4

JSC conducts internationally recognized research in the areas of bioastronautics, space science and astromaterials. Specific disciplines include crew health and safety; bioastronautics; biological sciences and their applications; biomedical experiments and technologies; astromaterials; and exploration sciences. These disciplines and the scientific research that is conducted at JSC are described in more detail below.

Crew Health and Safety Program Support 4.4.1

JSC is responsible for optimization of the health, fitness and well-being of flight crews and Center employees. Specific responsibilities include providing state-of-the-art programs and evidence-based medical care; and defining, implementing and managing operational medical research and development.

Products and Services Related to Human Factors

- Environmental standards and requirements for air, water, microbiology, radiation and acoustics
- Human systems standards and requirements
- Support to development and operations for Shuttle, ISS and advanced human space flight programs
- Flight food systems
- Research and technology development in environmental monitoring and human factors

JSC defines the medical requirements and standards for astronaut selection and retention, as well as astronaut physiological and psychological support. The Center also delivers medical care to the crews by providing diagnostic and medical treatment to astronauts through all phases of preflight training, during on-orbit operations through telemedicine, and during postflight recovery and rehabilitation. Finally, it provides continuous mission support from launch to landing for maintenance of crew health and safety.

JSC operates a medical clinic, the Flight Medicine Clinic, that provides comprehensive annual medical evaluations for all active astronauts and medically certifies all assigned Shuttle and ISS crewmembers for space flight. In addition, the Flight Medicine Clinic provides medical, dental and psychological support to all astronauts, astronaut family members and aircraft operations personnel. The Health Stabilization Program is managed and implemented through the Flight Medicine Clinic to minimize the affect of communicable disease on the crews. Retired astronauts are offered an annual comprehensive medical evaluation as part of the Longitudinal Study of Astronaut Health program.

Behavioral medicine provides clinical care and clinical oversight to astronauts and their dependents. Additionally, contingency support in the aftermath of disasters is offered and delivered to families, educators and casualty assistance control officers. Crew performance management is offered to all flight crews, and crew health training and behavioral health monitoring are conducted for all NASA ISS crewmembers. Oversight of "human-to-systems" interfaces—including the development and implementation of work-rest recommendations, fatigue models, fatigue countermeasures and the assessment and recommendations of methods for crews to maintain skills on orbit—is also provided to the Themes. Similarly, sleep and circadian rhythm recommendations are developed and delivered to optimize on-orbit schedules and assessment of workload limits.

JSC is responsible for ensuring a safe, habitable and productive environment for human space flight through its human factors expertise. The ultimate goal is to identify and control all environmental risks to crew health, and to have a habitat and human-system interface that enhances crew productivity.

Bioastronautics 4.4.2

JSC's research in bioastronautics—on Earth and in orbit—strives to understand and reduce the barriers to human activities in space and on other planets. The Center is the implementing NASA center for bioastronautics, a coordinated Agency effort that spans several Agency Themes.

The Center's bioastronautics research on the physiological effects of space flight is guided by the Bioastronautics Critical Path Roadmap (BCPR), an iterative approach of review, analysis and deliberation among discipline experts. Jointly developed by NASA and the National Space Biomedical Research Institute (NSBRI), the BCPR identifies and ranks the risks of space flight mission scenarios for the allocation of resources to minimize the overall risks of space flight. The original 55 risks and 250 critical questions identified in 1997-1998 for an exploration-class mission scenario are currently being updated and refined by NASA and NSBRI scientists, based on recent space flight and ground results, to be relevant to a one-year ISS mission and a one-month lunar surface mission.

Medical personnel practice on a human patient simulator to develop procedures for the Health Stabilization Program.

JSC performs a wide range of functions to answer critical questions in the area of bioastronautics. These questions include:

- How does the human body adapt to space flight, and what are the most effective and efficient ways to counteract those adaptive effects when they are hazardous?
- How can we limit the risk of harmful health effects associated with exposure of human explorers to the space radiation environment?
- How can we provide an optimal environment to support the behavioral health and human performance of the crew before, during and after space flight?
- How can we enable the best medical care in space?

JSC's biomedical research capability leads and complements the NASA-funded efforts of other scientists and organizations, such as the NSBRI. Scientists at NSBRI conduct physiological research in cardiovascular, neurovestibular and barothermal physiology to help answer the critical questions of bioastronautics. In addition, the Center's occupational health program provides medical training and monitoring for any test or training activities conducted in hazardous environments, such as the NBL, the thermal vacuum chambers, the hypobaric training chambers and the KC-135 aircraft.

To facilitate additional answers to bioastronautics-critical questions, JSC developed the Human Research Facility (HRF) to enable life science researchers to study and evaluate the physiological, behavioral and chemical changes in human beings induced by space flight. The HRF consists of equipment racks containing: an ultrasound imaging system and a mass spectrometer that can enable cardiopulmonary and metabolic experiments; a space linear acceleration mass measurement device that allows precise measurement of the changes in crew mass; the refrigerated centrifuge that collects physiological samples such as blood and urine to be centrifuged in a cooled environment for subsequent storage until return to Earth; a urine monitoring system to automatically measure micturitions and enable easy sample collection; and a muscle atrophy and resistive exercise system to measure changes in muscle strength. These research capabilities will enable researchers to conduct selected investigations by using equipment already on board the ISS and to reduce cost and development time to flight readiness.

Biological Sciences and Applications 4.4.3

JSC is the designated implementation site for basic and applied cellular research, particularly as this research addresses innovation in biotechnology.

Astronauts Kenneth D. Cockrell (left) and Paul S. Lockhart, STS-111 mission commander and pilot, respectively, participate in one of the STS-111 detailed test objectives involving the biotechnology water treatment system. The purpose of this test is to produce ultra-pure water from the Shuttle's fuel cell water. This water, when processed, can replace manifested ultra-pure water supplies, and significantly decrease the mass and volume required to support biotechnology payloads.

Biological Sciences and Applications (BSA) was created to facilitate integration of cell-based research into the overall strategy of the Biological and Physical Research Enterprise. In this era of molecular approaches to life systems, it is essential that our planning includes an intensified program in cell-based research and molecular biology.

BSA uses an interdisciplinary approach to research that entails applying both physical and biological sciences to complex problems in biotechnology. As part of this approach, it conducts nationally recognized efforts in tissue engineering, biomolecular physics, biophysical separation technology and biological macromolecule crystallization. BSA coordinates its research in bioastronautics with NSBRI, the National Institutes of Health, the National Science Foundation, the Department of Defense, academic centers, NASA's Ames Research Center, NASA's Glenn Research Center and NASA Headquarters.

BSA will coordinate the research interfaces and develop research thrusts that serve the needs of bioastronautics, enable technology exchanges and advance NASA technology and science in biotechnology and biomedicine. These relationships will ensure that JSC is an essential participant in the growth of the technology industry.

Attainment of these goals is closely tied to the Center's commitment of consistent support of BSA to continue to advance technology, to explore new science fields and to contribute to NASA's reputation for innovation.

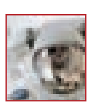
Biomedical Experiments and Technologies 4.4.4

NASA has inaugurated a new era in long-duration human space flight with the construction and habitation of the ISS. With ISS expeditions increasing from days to months, crewmembers face a concomitant increase in the number and complexity of risks to their safety, health and performance. To effectively and efficiently prevent the most severe risks of human space flight, JSC develops, evaluates, validates and certifies an integrated countermeasure approach. Countermeasures may include pharmacological agents, dietary modifications, exercise, mechanical stimulation, artificial gravity devices, or changes in the crew screening and selection criteria. In addition to mitigating or minimizing risk, a countermeasure must also meet stringent specifications for use in flight, where resources and crew time are equally scarce.

All countermeasures first undergo a rigorous cycle of ground-based and flight investigation prior to being certified for operational use. Furthermore, countermeasures initially developed for flight may further the development of preventative, diagnostic and medical treatments on Earth. Because of the limitations of space flight, NASA is particularly interested in easily portable, minimally invasive diagnostics and countermeasures. These characteristics are also of great value on Earth to telemedicine centers and clinics that distribute medical care across significant distances to remote locations. By learning how to counter the most detrimental effects of space flight, NASA also fosters better treatment methods for the elderly, whose ailments resemble some of the physiological changes manifested by crews after prolonged space flight.

JSC also designs, develops and certifies unique biomedical payloads and countermeasure devices for space flight, such as the cycle ergometer with vibration isolation system the treadmill with vibration isolation system, and the interim resistive exercise device, to prevent or reduce the adverse adaptive changes of the human body in a space flight environment. This design capability provides a flight hardware knowledge base that can be readily and effectively applied to payloads and experiments. JSC has unique flight hardware laboratories and controlled ground support equipment currently used for checkout and test of ISS and Shuttle GFE, as well as individual experiments or payloads.

JSC is also responsible for the design and development of a ground-based equivalent of the on-orbit hardware and software for procedure development and verification, anomaly resolution, interface verification and equipment upgrade testing. Collaborative engineering centers provide the



capability to perform integrated design from multiple locations, both internal and external to JSC, so that all responsible parties for a particular experiment or payload development can be involved.

Astromaterials Research and Exploration Sciences 4.4.5

The Office of Astromaterials Research and Exploration Sciences provides products and services to the Space Science Enterprise's Themes, including Solar System Exploration and Mars Exploration.

Extraterrestrial Materials and Research

JSC is responsible for curation of all extraterrestrial materials returned to Earth by missions. For more than three decades, JSC has safeguarded and administered the Lunar Sample Collection returned to Earth by the Apollo lunar landing missions.

As NASA's curator of extraterrestrial materials, JSC curates lunar samples, meteorites and cosmic dust. Included in the Center's collection are meteorites gathered in the Antarctic—almost certainly from Mars—that provide fascinating evidence that primitive life may once have existed on the Red Planet.

Through an agreement between NASA and the Smithsonian Institution, thousands of meteorites collected in Antarctica are curated at JSC. Interplanetary dust particles collected in the stratosphere by high-altitude spacecraft form another exotic, but scientifically valuable, collection. Future missions returning samples include Genesis, now stationed between the Earth and the Sun to collect solar wind particles; and Stardust, now heading for a rendezvous with a comet. Samples from these collections are disbursed to scientific investigators after approval by scientific peer-review panels and NASA program managers.

This close-up view of the eye of Hurricane Isabel was taken by one of the Expedition 7 crewmembers on board the International Space Station.

JSC has a staff of internationally recognized researchers in the fields of lunar sample analysis, meteoritics and planetary remote sensing. Center scientists have been responsible for establishing the provenance of meteorites from Mars and have pioneered the field of astrobiology through the discovery of potential biomarkers within certain martian meteorites. JSC staff scientists are key members of scientific teams for ongoing and future missions to Mars and the Moon.

JSC also conducts studies of the implementation of science goals in future human missions and the interaction of human and robots in future planetary expeditions.

Earth Observation

JSC contributes to our understanding of the Earth's systems by planning and cataloguing on-orbit photography from human crews. Scientists at the Center study the Earth using information that is gathered by astronauts trained in Earth observations. While in orbit, astronauts record data and collect imagery on weather and other Earth phenomena. NASA has compiled a database of more than 350,000 photos of the Earth taken by NASA astronauts.

JSC leverages its scientific expertise to maintain a significant education and public outreach effort. To this end, it has developed curricula for schools in the subjects of planetary exploration and meteorites. The crew Earth-observation database makes a strong connection with the public. During the summer months, JSC hosts many teachers learning about planetary science and many students working on research topics.

Orbital Debris

Through its orbital debris research and its risk assessment team for hypervelocity impacts, JSC also enhances the safety and reliability of missions in both low and high Earth orbits. JSC is the unique source of debris environment modeling. It has worldwide leadership responsibility in policy and matters of debris mitigation and environmental control. The Center also provides risk and threat assessments, impact testing and shielding development based on orbital debris research and analysis.

Educator Astronaut Barbara Morgan, ISS spacecraft communicator (CAPCOM), is photographed in the ISS flight control room in Houston's Mission Control Center during the STS-105 mission.

Education and Scientific Knowledge Advancement 4.5

An important component of JSC's work includes education and advancement of knowledge. JSC is committed to teaching students and sharing its research with scientists, students and researchers across the world. The programs that support these activities are described below.

> *NASA and teachers share the same mission —to explore, learn, and to share.*
>
> –Barbara Morgan
> Educator Astronaut

Education and Student Programs 4.5.1

While education has always been a part of NASA, designating education as a part of the core mission of the Agency allows NASA to emphasize education in a way that NASA has never done before.

The Agency's Education Enterprise has established strategic objectives and specific goals to increase involvement in NASA-related education programs by educators, students and families across the country. The ultimate goal of this activity is to increase the number of students going into science, technology, engineering and mathematics professions. JSC is deeply committed to supporting the Agency's Education mission and will do so by designing and implementing programs to meet these stated objectives and goals with audiences representative of America's diversity.

Specifically, JSC will play key roles in supporting new Agencywide initiatives such as the Educator Astronaut and Explorer Schools programs.

Educator Astronaut

The Educator Astronaut program is a bold new program to send educators into space as fully trained astronauts. In 1996, the Agency selected Barbara Morgan to be the first Educator Astronaut. In the near term, JSC will be responsible for the final selection and training of the next cadre of Educator Astronauts. This program is about inspiring future explorers through the excitement of human space flight and other NASA activities. JSC will work with the rest of NASA and its partners to build on the current Teaching From Space program and to develop a broad Educator Astronaut program that will meet Agency objectives.

Explorer Schools

NASA has initiated the Explorer Schools Program to strengthen career development in science, technology, engineering and mathematics and to meet individual needs of schools. Explorer School teams, working with NASA personnel and other partners, will develop an action plan that addresses a local need in mathematics, science or technology, incorporating NASA data and materials into the curriculum. NASA JSC will serve as the resident center for five Explorer Schools. In addition, JSC will serve as one of three hubs of the developing NASA Digital Learning Networks, which will make use of videoconferencing and other technology to deliver NASA content to Explorer Schools. This activity has the potential to reach millions of students in addition to the hundreds of other audiences already served annually via the Distance Learning Outpost located at JSC.

Students with an interest in science, technology, engineering and mathematics are supported through the Agency's Education Enterprise.

As well as supporting the Agency's new strategic initiatives, JSC will continue to implement other national, regional and state-based activities for university, kindergarten through grade 12 and informal education audiences. On a national level, programs such as the Graduate Student Researcher Program and the KC-135 Reduced Gravity Student Flight Opportunity Program will continue to engage university students in NASA-related research. Within an eight-state surrounding region, the Pre-Service Teachers Institute for underserved teacher candidates will continue to prepare educators for their role in the classroom by exposing them to real math and science applications at NASA. Within Texas, the Texas Aerospace Scholars Program will also continue to encourage students who have a desire to learn more about technical careers, but may have not yet decided to pursue a career in the fields of science, technology, engineering or mathematics.

Through "real-life" experiences, working alongside NASA engineers, scientists and business professionals, JSC's student employment and recruitment programs will continue to develop qualified and diverse graduates to expand the pool of human capital available to meet the vital workforce needs of NASA and the United States.

Exemplary Education Programs

To ensure alignment of all education programs with the NASA strategic objectives and desired outcomes, the Education Enterprise established the "Criteria for Exemplary Education Programs." Every NASA-sponsored education activity will evaluate its appropriateness and effectiveness in relation to six dimensions. These dimensions are Customer Focus, Diversity, Evaluation, Partnerships/Sustainability, NASA Content, and Workforce Pipeline. JSC will use these six criteria to continually evaluate its education programs to ensure that JSC is aligned with the Agency's overall direction.

Technology Transfer 4.5.2

Part of NASA's purpose is to transfer the technology it develops to the private sector for applications that will foster U.S. economic growth and development, and that will benefit people throughout the nation and the world by improving life on Earth. Space-based technology has already enriched a wide range of human activities, including:

- Communications.
- Information processing.
- Transportation.
- Environmental studies.

NASA technology has improved the quality of life on Earth with advances in biotechnology, medical applications, agriculture and more.

JSC's objective is to effectively transfer technology to the nation, primarily through developmental partnerships and licensing agreements with business and industry. In collaboration with other NASA field centers, JSC implements the ITTP program and manages the Center's intellectual property assets by identifying, capturing, monitoring and protecting technology, and by facilitating the joint development and transfer of technology at the earliest feasible point in the development cycle.

Unique Center Support Services 4.6

JSC is committed to supporting the NASA initiative to consolidate common business functions across the Agency as One NASA. The Agency anticipates consolidating certain business functions under the NASA Shared Services Center in areas such as facilities, human resources, procurement, financial and resources management, and information technology. JSC provides some unique support services for the Agency programs in the areas of imagery and publishing; procurement; and budgeting and financial planning. These unique services are described in more detail below.

Imagery and Publishing 4.6.1

Imaging technologies are merging at a steady pace and moving toward fully using an information technology platform. Still photography continues moving away from chemical-based processing and toward digital imaging. As recently as two years ago, only 50 percent of the imaging processing was conducted using digital systems; today, more than 75 percent of image processing is digital, with chemical processing expected to be down to almost

zero percent in three years. Video media also continues to evolve toward a digital format, as well as capitalizing on enhanced network capabilities and systems infrastructure replacement to improve recording and distribution methodologies.

JSC is moving aggressively toward maximizing the use of new computer-based technologies in its imaging sciences area. JSC, by working to enhance capabilities in both video and still photography, is partnering with its customers, such as the ISS and Space Shuttle programs, to implement more efficient digital solutions that bring added capability with reduced overall operating costs.

JSC also leads NASA in its digital production capability. For the remaining wet-film processing still being performed, JSC, as a direct result of installation of a zero-discharge system, also leads the Agency in minimizing the chemical waste produced.

Procurement 4.6.2

JSC provides procurement products and services in support of the NASA programs resident in Houston, Texas. It allows the management of an unprecedented number of major program and institutional acquisitions that are increasing the competitive base, including small and small disadvantaged businesses, from which NASA purchases program goods and services. JSC continues to improve performance, through the use of risk-based contract surveillance and management, and the overall acquisition process, through increased and enhanced contactor communications.

The Center plans to augment its procurement capabilities through implementation of e-Government tools and to enhance competitive opportunities and efficiencies while maintaining high customer ratings. A One NASA acquisition process, which uses processes and tools designed to integrate and improve contract cost as well as technical and management performance, is expected to improve contract management. JSC will improve its services to the resident NASA programs through increased use of contract and incentive strategies targeted to specific program goals, and through increased use of competitive sourcing as a way to achieve maximum performance.

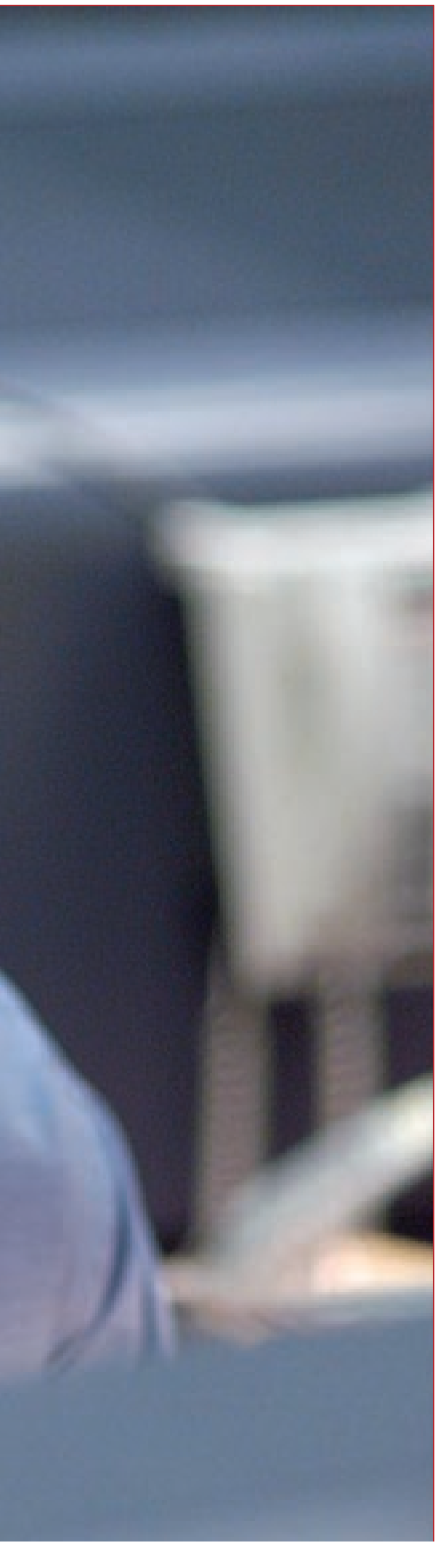
Budget/Financial Planning 4.6.3

JSC provides financial planning and budget execution products and services for NASA programs resident at the Center. The Center is responsible for implementing the financial and resources systems required for proper data collection and reporting as well as ensuring that Agency- and Center-level financial and resource decisions are implemented properly. Managers review, approve and implement financial and resources policies and integrate the planning, implementation, management and control of all resources for which JSC is responsible.

Cost estimating and analysis capabilities are provided for all programs that reside at the Center, including Space Shuttle, ISS and Bioastronautics. In addition to the actual analysis of project and program performance, these capabilities promote the effective use of advanced project management analytical tools and processes for improving cost, life cycle cost and schedule estimating and assessment capabilities. Resources management organizations are responsible for developing and integrating budgets for all projects and program offices that reside at JSC, as well as executing the current year budget.

Over the next three years, the Center plans to further develop program and project assessment capabilities and to continue to emphasize the integrated budget and performance analysis. The next modules in the Integrated Financial Management Program will be implemented in accordance with the Agency schedule, including Budget Formulation and Integrated Asset Management. The Agency will begin full cost operations in 2004, and the Center will continue to improve its capabilities to manage and report in full cost.

5 Implementing Strategies (IS)



5 Implementing Strategies (IS)

IS-1: Achieve management and institutional excellence comparable to NASA's technical excellence.

Human Capital Management

JSC is dedicated to achieving managerial and institutional excellence that is comparable to the high level of its trademark technical excellence. The Center recently rolled out NASA's Strategic Human Capital Plan (SHCP), which established a systematic, Agencywide approach to human capital management that aligns with NASA's mission and vision. The SHCP provides an integrated approach that will enhance the Agency's ability to work together as One NASA. The plan places an emphasis on the fact that people are as important as other resources.

JSC is currently involved in a number of initiatives in support of the SHCP. JSC:

- Developed the NASA Organizational Profile System, a Web-based tool that extracts key human resources data for JSC organizations.
- Created the JSC Workforce Representation System, which is a tool that compares specific diversity elements of JSC's current workforce against the relevant civilian workforce in the U.S. Census.

Astronaut Robert L. Curbeam, Jr., spacecraft communicator (CAPCOM), monitors data at his console in the Shuttle flight control room in Houston's Mission Control Center during the STS-105 mission.

- Is actively involved in the design and development of the Agency Competency Management System.
- Uses the cooperative education program to address its aging workforce issue. Cooperative education students (Co-ops) comprise the majority of new hires into entry-level technical and administrative positions at the Center, accounting for 34 percent of FY 2002 hires.
- Is completing the pilot year of its mentoring program. This program was created to facilitate personal and professional growth. Mentors and protégés have the opportunity to share experiences and lessons learned, as well as to gain new perspectives on the work environment and to expand networks and relationships. Data are being collected on participant experiences to improve the program for future participants.
- Conducts the Oral History Project, which continues to serve as a component of the Center's knowledge management efforts. More than 170 interviews have been conducted and archived to date.
- Is implementing a pilot JSC Leadership Development Program to provide a proactive approach to developing highly talented people and increasing JSC's leadership quality.

Competitive Acquisition

JSC routinely conducts competitive acquisitions in producing products and services at the Center. JSC leverages both industry and academia through cost-effective arrangements to obtain the best value to the government. JSC is committed to augmenting its use of competitive acquisition procedures to enable efficiencies for the Themes and projects at the Center.

Streamlined Financial Management

The Center plans, implements and evaluates integrated financial management program and financial systems. It is responsible for reporting, controlling and analyzing financial data on a full-cost accounting basis, as well as advising Center personnel on all financial matters. This consultation includes providing financial services, resources control and automated financial systems, as well as cost accounting, reporting and property management.

IS-2: Demonstrate NASA leadership in the use of information technologies.

Converged Networks

Currently, voice, video and data are distributed throughout JSC over three different systems. JSC's vision is to move these services from three separate institutional networks to a single network infrastructure. Media convergence cost savings in productivity will be realized by simplifying information access and reducing maintenance.

Network Traffic Shaping

JSC is transitioning focus from network connectivity to network management to provide better network performance. This transition requires the development and implementation of tools for network traffic shaping. As new services—such as video and voice—are added, these new capabilities are needed to assist JSC in monitoring, maintaining, troubleshooting and growth planning of its networks. Network slowdown or outage is very critical for productivity and mission-critical applications. These real-time network diagnostic tools enable JSC to collect information to obtain the performance characteristics of the network.

One NASA Messaging

JSC implemented and currently manages Phase I of the One NASA Messaging Vision. One NASA Messaging is intended to eventually integrate all NASA personnel within a single electronic messaging infrastructure. This infrastructure is expected to simplify collaboration among NASA field centers and speed the daily exchange of information. During Phase I, JSC removed center-specific designations from all NASA email addresses, resulting in simplified @nasa.gov addresses. All NASA external mail is routed through computer systems at JSC. While it continues to maintain this system, JSC is also participating in Phase II, which is intended to convert the Agency to entirely new messaging software.

Web Hosting

Growth in the size and number of general Web applications has been ten percent per year for the majority of application systems supported by JSC. Server obsolescence and workload consolidation and balancing are the primary drivers underlying a three-year replacement cycle for processing platforms.

Activities are under way to replace the aging application server infrastructure with newer, mid-range platforms. Most notably, the architecture is being revised to allow for separation of developed and commercial-off-the-shelf workloads to reduce the number and likelihood of integration problems. Staging and integration environments are also being introduced to improve the effectiveness of testing and the overall quality of production systems.

Document and Data Management

The Design and Data Management System and Electronic Document Management System represent the most notable areas of growth for JSC applications support through 2004, with additional growth anticipated in 2004 and beyond. As more and more interest is focused on the ability to better manage the life cycle of engineering design data, as well as streamlining and improving the methods for managing documentation life cycles in general, this initiative is clearly an area on which JSC plans to place considerable emphasis.

Efforts are already under way to analyze key activities to develop an overall JSC Information Management System. This system will enhance the Center's ability to provide timely access to the most accurate information from across the Center. Architectural changes in this area will be driven by system reliability, availability and interoperability requirements as necessary.

IS-3: Enhance NASA's core engineering, management and science capabilities and processes to ensure safety and mission success, increase performance and reduce cost.

Collaborative Engineering

JSC has established multiple collaborative engineering centers that make it possible to achieve a high level of design fidelity even in the early conceptual stages of a project. This is done by facilitating the participation of multiple designers in each phase of design and development. These centers are being used effectively by diverse and distributed engineering teams to develop integrated design solutions for projects to conduct integrated engineering analyses and to perform integrated trouble shooting.

Process Management

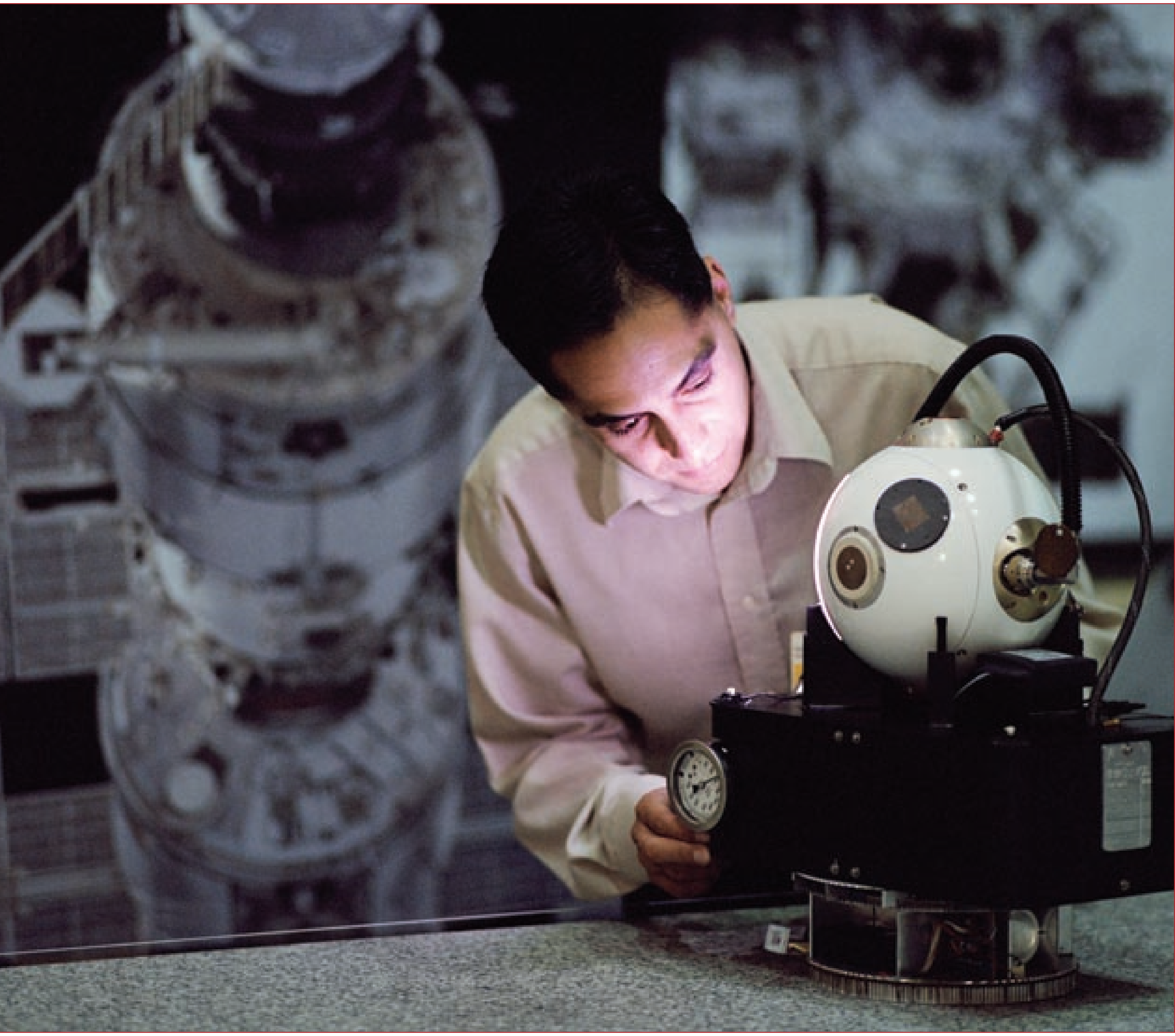
JSC is using computer-based workflow and data management tools to streamline multiple technical and administrative processes. These tools provide the additional benefit of ensuring compliance with established procedures and processes, thereby increasing the quality of engineering products and services.

JSC's lessons-learned process has documented critical processes and procedures to capture both requirements and "best practices" to improve engineering's technical, cost, schedule and safety performance and quality. These processes and procedures are tailored to the needs of all engineering projects based on safety, scope, complexity, cost and acceptable risk.

Systems Engineering

JSC is continuously seeking to develop, maintain and enhance its systems engineering and support to the programs and projects of today and tomorrow. This support includes skills and expertise, technology and facilities. The Center seeks to provide its customer programs and projects with the right:

- Resources by using the required engineering and technology development skills, experience and expertise at the right time.



Systems test for the MiniAERCam Project.

- Test, analysis and crew training facilities, at the right cost and schedule, throughout the program or project life cycle.
- Technologies, at the right development level, at the right time, within cost and on schedule.

Common position skills and expertise criteria were established for each core capability to ensure training and hiring in key areas of immediate needs, to:

1. Implement capability and process changes necessary for Shuttle RTF and implementation of the CAIB recommendations.
2. Strengthen selected civil service core competency skill areas to better support current and future programs.
3. Provide safe mission operations on time and within cost for completion of the ISS U.S. Core Complete configuration.
4. Participate in OSP definition and design to assure its operability and efficiency. JSC will also establish supportive mission operations expertise to accomplish all assigned OSP mission operations functions.

Safety and mission assurance engineers directly participate in the resolution of hardware and software problems on the ground and on orbit to ensure that corrective and preventative action is properly documented and implemented. Early involvement by quality engineering ensures that designs are producible and testable, and can be manufactured in the highest quality manner.

Direct involvement in manufacturing and test activities on site at JSC by the quality assurance function ensures that hardware and software produced by JSC conform to all physical and functional requirements. Off-site manufacturing and tests are carefully monitored through implementation of surveillance plans and periodic audits.

JSC has developed and implemented a Safety, Reliability and Quality and Mission Assurance Training Academy Web site to provide a comprehensive training resource and tool to identify technical and management skill gaps. Available training and training requirements are identified for the novice, intermediate and expert levels for quality assurance specialists, engineers, technical leads, managers and administrative support.

Peer Review

JSC emphasizes maintaining and continuously improving the Center's core capabilities in science, engineering and technology. Through disciplined peer review processes, JSC ensures the quality and integrity of its scientific research, engineering projects and technology development. This emphasis is reflected in multiple efforts that are and will be providing significant benefits in the reduction of life cycle costs and technical, cost and schedule risk and in improved quality of scientific research.

IS-4: Ensure that all NASA work environments, on Earth and in space, are safe, healthy, environmentally sound and secure.

Safety and Health

JSC is committed to assuring the safety and health of crewmembers in space environments by using comprehensive system safety and risk-management processes throughout program and project life cycles. Hazards to crew health are identified through the system safety process and are eliminated or controlled to an acceptable level of risk. Existing crew health hazards and associated controls are identified in hazard reports. Controls include hardware design and operational procedures such as flight rules and crew procedures. Design changes that could impact crew health are evaluated through the engineering design and verification process. Operational changes that could impact existing hazard controls are evaluated through established program change review processes.

JSC's ground safety program ensures that all work environments are safe, healthy, environmentally sound and secure. The program is third-party certified through the Occupational Safety and Health Administration's Voluntary Protection Program (VPP). JSC was certified as a VPP Star site in 1999,

recertified in May 2003 and seeks to be recertified again in 2007. The VPP establishes world-class criteria for a comprehensive, robust and continually improving safety and health program featuring management leadership and employee involvement.

Many of JSC's contractors, which are also certified as VPP Star sites, are in the mentoring pilot program pursuing certification or are participating in the survey/review process. This strong participation increases the effectiveness of the overall program. Key elements of the JSC safety and health program are:

- Management, labor and employee teaming.
- Finding hazards.
- Eliminating and controlling hazards through risk management.
- Training and equipping employees to work safely.

Comprehensive training of employees in personal protective equipment and emergency response procedures ensures that employees are prepared and equipped to work safely. Continuous improvement initiatives target reducing injury and illness rates, eliminating hazards rather than controlling hazards, and implementing better training techniques to further enhance hazard recognition and avoidance by employees.

JSC offers comprehensive occupational, preventive and emergency medicine services for eligible civil servant and contractor employees. The Center also provides recognition, evaluation and control of chemical, physical and biological stressors in the workplace. This includes, but is not limited to, indoor air quality, potable water quality, ionizing and nonionizing radiation, ergonomics, hazard communication and other public health concerns.

Environmental Management

JSC, including its satellite facilities, is in the process of implementing an environmental management system (EMS) that:

- Provides a systematic evaluation of environmental impacts of our activities and programs.
- Evaluates compliance with applicable regulations, Agency requirements and Executive Orders though self-evaluation and auditing.
- Supplies a mechanism for implementing and tracking corrective action.
- Accomplishes continuous improvement by setting objectives and goals for the environmental program.
- Includes management review for effectiveness and adequacy.

JSC's goal is to complete implementation in accordance with the Agency requirements for an EMS by 2004 and to meet federal Environmental Protection Agency (EPA) Performance Track requirements by 2005. WSTF has completed implementation of an EMS including ISO 14001 and EPA Performance Track certifications. The overall objective of the EMS is to ensure compliance, to reduce any negative effect on the environment and to eliminate financial impact by avoiding liability from such action.

JSC provides information on environmental issues to employees via Centerwide forums such as Safety and Total Health Day, Contractor Affairs Subcommittees and the Executive Safety Committee. The Center uses a cross-organizational team, the JSC Environmental Stewardship Subcommittee, to discuss environmental topics affecting JSC and to develop strategies to achieve compliance and meet JSC's environmental objectives.

The environmental office collaborates with other organizations to develop and implement pollution prevention and reduction activities. In addition, JSC is evaluated for compliance though federal, state and local inspections from regulatory agencies and through periodic NASA environmental functional reviews.

Security

JSC protects its assets by controlling areas through the use of perimeter fencing and entrance/exit gates where positive identification and badge checks are performed prior to entering the site. Roving patrols are used to check the fence, and a project is under way to increase the closed-circuit television (CCTV) system capabilities to more thoroughly survey the gates and fence.

The physical security of JSC has been undergoing significant upgrades since September 11, 2001, with increased numbers and proficiency of the guard workforce, additional physical security equipment, and upgrades to hardware and software security systems. JSC officials continually evaluate the site for additional enhancements.

JSC assesses its infrastructure security using the Minimum Essential Infrastructure (MEI) protection plan. MEI protection planning identifies mission-critical facilities and determines the resources necessary to ensure sufficient protection of facilities, systems and personnel. Additional security measures exist within MEI facilities and laboratories.

The Center has partnered with local, state and federal officials for both emergency response planning

Astronaut Stephen K. Robinson, STS-114 mission specialist, wears a training version of the extravehicular mobility unit spacesuit during an underwater simulation of extravehicular activity scheduled for the 17th Shuttle mission to the International Space Station.

Astronauts Jeffrey S. Ashby (left) and Pamela A. Melroy, STS-112 mission commander and pilot, respectively, along with an instructor, are photographed in the cockpit of a KC-135 aircraft at Ellington Field near JSC. Although used primarily for the Reduced Gravity Program at JSC, the large aircraft also fits the bill for heavy aircraft familiarization. Most training for Shuttle landings takes place in the Shuttle Training Aircraft, which is much lighter in gross weight than the Shuttle. Astronauts practice landings in the KC-135 since it is more similar in gross weight to a Shuttle.

and security of the site. JSC security officials attend regular forums with community partners. The Emergency Operations Center is open to community partners during times of crisis. Lines of communication are open between JSC and its partners; and JSC management is notified of any concerns affecting the Center or personnel. JSC is prepared to respond accordingly.

Protection of government property from theft or damage is performed by securing assets within the controlled perimeter of the site. Additional controls are in place where assets of high value are protected using CCTV, additional locks or vaults, and, in some cases, additional guards to control entry/exit from these areas. Random vehicle searches are performed to ensure no unauthorized property is brought onto or removed from the site.

Release of government property for off-site use is controlled through the use of approval processes, including property release and property ownership transfer. Releases of government property are tracked through an inventory tracking system. Annual inventories of government property are performed, and results are reported to property custodians and Center senior management. Property custodians investigate lost property with the assistance of the security office. JSC consistently strives to meet the Agency goal of less than 0.5 percent of lost property.

IS-5: Manage risk and cost to ensure success and provide the greatest value to the American public.

Risk Management

A three-year outlook of JSC's Continuous Risk Management Program is being developed by the Center. This will include risk assessment tools, such as probabilistic risk assessment, for the Themes as well as training in risk management.

JSC is leading the Continuous Risk Management Program to provide support to all programs and projects at JSC. This initiative was driven by the requirements given in the NASA Procedures and Guidelines (NPG) 7120.5B, "NASA Program and Project Management Processes and Requirements." The type and level of risk management support depends on program maturity. Routine risk-related support tasks are provided as an integral part of the general risk management process in mature programs such as the SSP. For specialized tasks such as probabilistic risk assessment, JSC continues to serve as the experts for leadership and guidance in this area.

Risk management support and project risk management strategy are provided to the OSP Program and Project Office in accordance with NPG 7120.5B. A detailed design reference mission probability-of-success analysis is in development for the OSP portion of the program architecture.

As of 2003, risk management training was provided for over 460 JSC personnel using the Continuous Risk Management curriculum from NASA's Goddard Space Flight Center. In addition to providing certified instructors for the courses, the training also provides the ability to certify additional instructors as needed.

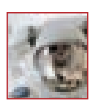
Cost Estimating

JSC provides cost-analysis services, including cost estimates, trade studies, schedule analysis, risk analysis and phasing, to its customers. Economic analyses of alternative investments for project management are also performed. The Center prepares hardware and software cost estimates for satellites, launch vehicles, spacecraft and projects related to the ISS, the Space Shuttle and other aerospace projects. JSC continually improves its cost models through development and modification of cost-estimating methods, algorithms and cost models required for the development of cost estimates for proposed NASA space projects. JSC also collects, analyzes, normalizes and maintains historical cost data for NASA space programs

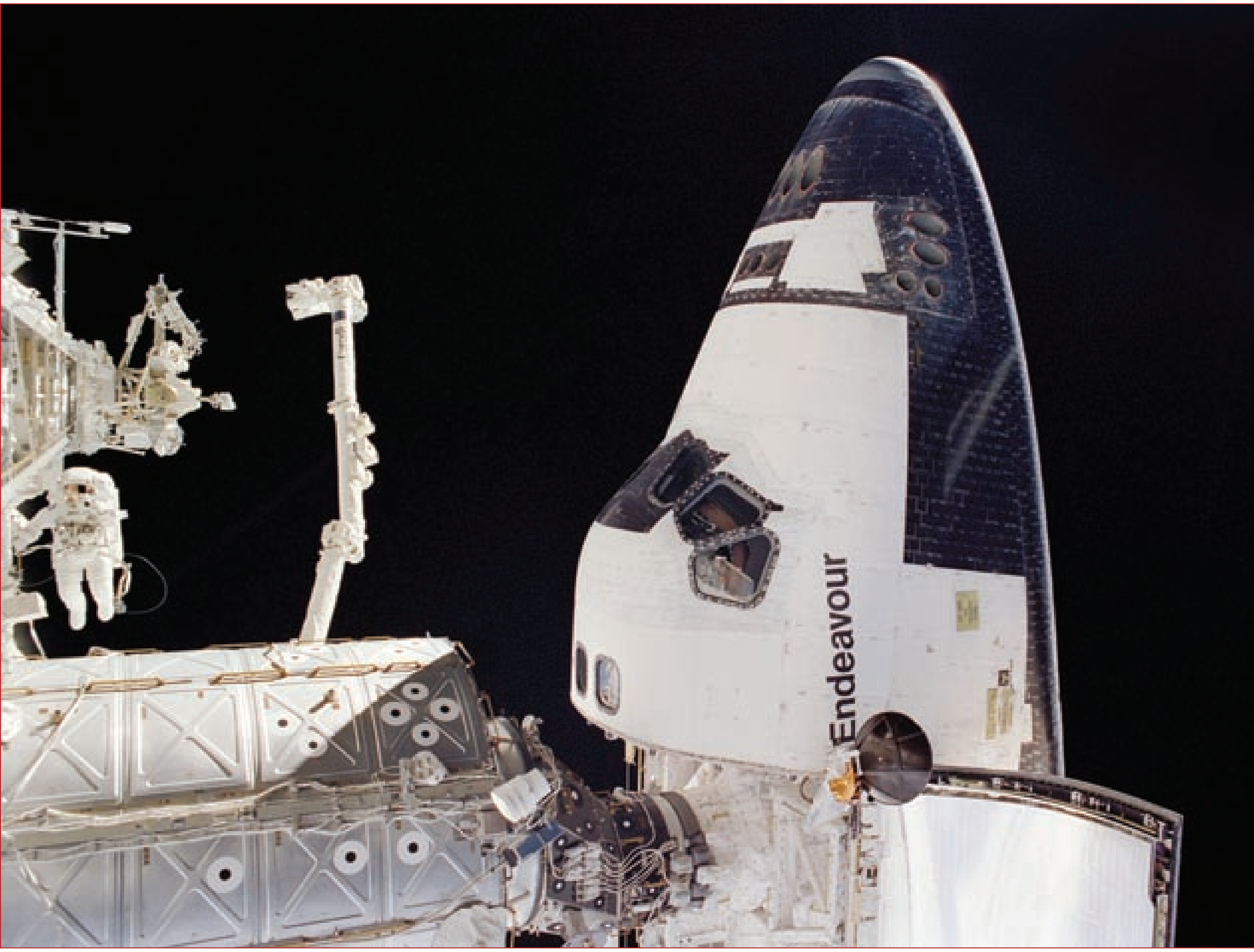
A quarter Moon is visible in this oblique view of Earth's horizon and airglow, recorded aboard the Space Shuttle *Columbia*.

Acronyms

ABF	Anthropometric and Biomechanics Facility
APU	auxiliary power unit
ARED	Advanced Resistive Exercise Device
ASO	Astronomical Search for Origins
ASPL	Advanced Space Propulsion Laboratory
AT	Aeronautics Technology
BCPR	Bioastronautics Critical Path Roadmap
BMAR	backlog of maintenance and repair
BSA	Biological Sciences and Applications
BSR	Biological Sciences Research
CAIB	*Columbia* Accident Investigation Board
CCTV	closed-circuit television
CMM	Capability Maturity Model
DOUG	Dynamic Onboard Ubiquitous Graphics
DSP	Display Software Package
EMI/EMC	electromagnetic interference/electromagnetic compatibility
EMS	environmental management system
EMU	extravehicular activity mobility unit
EP	Education Programs
EPA	Environmental Protection Agency
ESA	Earth Science Applications
ESS	Earth System Science
ESTA	Energy Systems Test Area
EUL	enhanced use leasing
EVA	extravehicular activity
FCI	facility condition index
FY	fiscal year
GFE	government-furnished equipment
GPS	global positioning system
GRAF	Graphics Research and Analysis Facility
HRF	Human Research Facility
IPS	Integrated Planning System
ISS	International Space Station
ITTP	Innovative Technology Transfer Partnerships
IVA	intravehicular activity
JAEL	JSC Avionics Engineering Laboratory
JSC	Johnson Space Center
LETF	Lighting Environment Test Facility
MEI	Minimum Essential Infrastructure
MEP	Mars Exploration Program
MSM	Mission and Science Measurement Technology
NBL	Neutral Buoyancy Laboratory
NPG	NASA Procedures and Guidelines
NSBRI	National Space Biomedical Research Institute
1-G	Earth gravity
OSP	Orbital Space Plan
RCM	reliability centered maintenance
PAD	Pad Abort Demonstration
PSR	Physical Sciences Research
RMS	remote manipulator system
ROBOT	Robotics On-Board Trainer
RPFS	Research Partnerships and Flight Support



RTF	return to flight
SAFER	Simplified Aid For EVA Rescue
SBIR	Small Business Innovative Research
SCDS	Spacecraft Dynamics Simulation
SEC	Sun-Earth Connection
SEPG	Software Engineering Process Group
SES	Systems Engineering Simulator
SEU	Structure and Evolution of the Universe
SFS	Space and Flight Support
SHCP	Strategic Human Capital Plan
SIGI	space integrated global positioning system inertial navigation system
SLEP	Service Life Extension Program
SLI	Space Launch Initiative
SSP	Space Shuttle Program
SSRMS	Space Station Remote Manipulator System
SSTF	Space Station Training Facility
SSV	Space Shuttle Vehicle
STTR	Small Business Technology Transfer
UTAF	Usability Testing and Analysis Facility
VASIMR	variable specific impulse magneto-plasma rocket
VPP	Voluntary Protection Program
WAFL	Water and Food Analysis Laboratory
WSSH	White Sands Space Harbor
WSTF	White Sands Test Facility
zero-G	zero gravity



Astronaut John B. Herrington (center left frame), STS-113 mission specialist, participates in the mission's third spacewalk. The forward section of the Space Shuttle *Endeavour*, docked to the Pressurized Mating Adapter (PMA-2) on the International Space Station, is visible center frame. The Station's Canadarm2 appears to stand between the Shuttle and Herrington.

National Aeronautics
and Space Administration

Johnson Space Center
Houston, TX 77058
JSC-49896

http://jsc.nasa.gov